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How Can Inquiry-Based Instruction be Implemented in a Secondary Mathematics Classroom?

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HOW CAN INQUIRY-BASED INSTRUCTION BE IMPLEMENTED
IN A SECONDARY MATHEMATICS CLASSROOM?

by

Jennifer Smith

A capstone submitted in partial fulfillment of the
requirements for the degree of Master of Arts in Teaching.

Hamline University
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CHAPTER ONE

Introduction

I have understood and explored education through multiple lenses. Beginning with my own experiences as a student, I often contemplated the most meaningful strategies for my own learning. Entering the classroom as a teacher, I pondered the same questions for myself and my learnings as a teacher, but incorporated a more intricate question around how to help my students learn best. I am currently a math coach and view teaching and education one step removed from the classroom with more space to reflect on theory and the opportunity to see my cohort of teachers sort through the same questions I encountered as a teacher.

In each experience I have gained new insight on learning and education. I came through education recognizing the impact of exploring content, rather than having it transmitted through direct instruction. I have seen this need in my own education, in the education of my students, and in the education of my teachers. Thus my question is: How can inquiry-based instruction be implemented in a secondary mathematics classroom?

The Way I Learned

Reflecting on my experiences as a student, I have encountered a vast array of teaching styles. Mostly, I have encountered teachers who handed me a textbook, assigned a reading assignment, lectured about the topics covered in the reading, and then asked my classmates and me to reproduce the procedures covered on an assignment, and later, a test. While this style of instruction forces me to claim ownership of my learning and to ask questions when I don’t understand, I operated as a computer. I collected information, memorized it, called on the memorized facts when necessary, and cleared my memory to make room for new information. This technique allowed me to earn acceptable grades, but did not set me up for success in life. It
also made it very clear to me that I was not a member of the learning community that held any knowledge about the content. While I didn’t realize it at the time, having my experiences in education be limited to this type of structure would play a large role in many components of my life in the future.

This transmission of knowledge from teacher to student was especially prominent in my math and history classrooms. In each, the structure of the class period was very predictable, but not in a way that benefited my learning. Every day, I entered the classroom, found my seat, took out my homework and notebook, and prepared to take notes. For the next 40 minutes, I watched as my teachers wrote and listened as they explained. The remainder of the class period was time to work on my homework and ask questions. As a result, many of my notebook pages were lined with a countdown of the number of minutes left in class. As long as I had copied down all of the notes written on the board, I was in a position to do well on my homework and tests. Afterwards, I could, without repercussions, forget this information and move on to the next unit.

This experience characterized the vast majority of my high school career. The only time I remember encountering hands-on learning was in my sciences classes. In these classes I tested DNA, designed new technology, and created experiments. Each of these required extensive use of problem solving skills and creativity. These moments are not only the experiences I remember the most, but they are also the objectives and standards that I remember content from. I remember what I learned and how I learned it.

While I felt successful in high school, the foundation of “how I learn math” was shaken as I entered college. For the first time, I was asked to explore content and apply my understandings to real-world scenarios. My first math class in college included a lecture and lab component. I was shocked and confused by the existence of a lab component in a math class. My
professor held high expectations, through both independent and group work, for the analysis of data and application of learning that took place during the lecture component of class. This is one of the first moments where I could identify my ownership of my learning in a math classroom.

The Way I Teach

When I entered the classroom as a first-year mathematics teacher at an inner-city charter high school, I found it was easiest and most familiar to use the “computer” style of teaching. I would model the procedure of solving a specific problem and ask my students to repeat this procedure over and over, until I believed they had grasped the concept. What I didn’t comprehend was that reproducing a procedure is vastly different from truly understanding a concept. My students, like myself at their age, became very good at memorizing and forgetting. I watched many of my students fail the state test at the end of the year because they had merely memorized the route procedures I had shown them. Like computers, our memories seem to only handle so much, before we begin to make room for new procedures by forgetting the old ones. My students also had no reason to attempt to retain the information beyond test day. They couldn’t see the purpose, and looking back, I sincerely can’t blame them.

Entering my second year, I realized that my role as a teacher needed to change. In order to make my students successful in school and in life, I needed to learn to guide my students towards knowledge, rather than handing them a platter filled with steps and rules. I began to introduce activities and labs that required my students to think critically about what they already know, and how it can be applied to what they are trying to understand. This structure was adapted from advice from mentors and a fellow math teacher at my school. The expectation of having students discover their own understanding pushed my students to actually learn the material, and to find joy in this learning. The latter seemed to have a larger impact on the way
my students viewed my class, their ability to learn mathematics, their roles and identities and
learners, and their interpretations of what was possible in the future.

The first activity I ever used that required students to be the owners and explorers of their
learning, sometimes called inquiry-based learning, required students to create a function that
described the height a bouncy ball returned to after being dropped from various heights. In this
way, students were attempting to find a pattern, and, in turn, practicing the fundamental
procedure of Algebra. As a first year teacher, the process of asking students to write a function
from a real-world scenario involved a word problem and an overly complicated procedure
involving tables. By allowing my students to observe the pattern, record the pattern, and truly
analyze the pattern through a discussion with their classmates, I gave my students the
opportunity to be critical thinkers. That skill is required to be successful in every classroom each
student enters, but also in each job he chooses to pursue and in the daily decisions he makes in
life. In being strong critical thinkers, my students became stronger members of society.

Yet, with so many other factors influencing my teaching, I often wonder if my students’
gains in academics were tied to this style of instruction. It has also crossed my mind that a
teacher learns a significant amount between her first and second years. In addition, I was
encountering a completely different set of students, with very different educational backgrounds.

My third year of teaching left me thinking about just how much I have to uncover about
myself as a teacher. I found myself analyzing which style of teaching best supports my students’
learning on a daily basis. How was I going to help my students gain knowledge, rather than
memorize facts? Was this style of teaching realistic considering the time constraints and
pressures to ensure students show growth on mandatory state exams? What does this style of
teaching look like in non-mathematics classes, and does it impact student learning? While I was
still not able to have answers to each of these questions, they shaped the way I perceived the classroom and the role of a teacher.

**The Way I Coach**

While I am deeply passionate about teaching and the importance of the role, after my third year of teaching I heard about an opportunity to become an instructional coach. In the spirit of broadening my impact, and recognizing the opportunity to become a stronger teacher through classroom observations and critical discussion, I decided to step out of the classroom and accept the position as an instructional coach.

The questions I encountered as a teacher stuck with me as I entered my current role as an instructional coach for teachers in urban school settings. As I supported first- and second-year teachers in contents ranging from 1st grade bilingual to 11th grade science, it became clear to me that my tendency to use my own learning experience as the foundation of my teaching experience was playing out in many of the classrooms I was working in. Being a first- or second-year teacher often results in many challenges. From behavior management to lesson planning, my teachers had a lot to balance.

While I had some experiences pushing my teachers to incorporate inquiry-based lessons, I didn’t have many resources to support a first-year teacher in successfully implementing inquiry-based activities successfully without my direct support in leading the lesson. Even then, challenges in behavior management often occurred as my teachers’ students were exposed to a style of teaching that was, for most, foreign and challenging. As I pushed my teachers to consider the same questions I was wrestling with, and as I learned more about the need for something different for students and teachers, I realized that my teachers’ students struggled with drastic changes in the styles of teaching they were so familiar with.
In my second year as an instructional coach, I am even more intrigued by the balance of student-centered learning and gradual release of this style of teaching with the hopes of producing optimal levels of student learning and retention. As I have worked with half of my cohort of teachers for a full year, I have a deeper understanding of their teacher identities and the needs of their students. While this has made me more successful at problem solving and thinking critically to be more responsive to the individuals I work with, I still have not had complete success in supporting my teachers in all elements of inquiry-based learning.

Uncovering what it takes to provide students with the opportunity to learn in the best way possible has become even more relevant as I plan to return to the classroom for the next school year. In preparation for this transition, I have developed my research question to determine how I can best support my students and their learning in my secondary mathematics classroom next year.

The research question that will be addressed in this capstone is a result of personal experiences as a student, a teacher, and a coach. As a student, I recognize the difference between learning math in high school, where a teacher lectured for the majority of the class period, and learning math in college, where I participated in a lab component that asked me to apply my understanding of content to a real world setting. Within my experiences as a teacher, this question stems from observations of my students as they learned new material, interactions with other teachers, and a desire to be prepared to provide my future students with the best education possible. Currently as a coach, I wrestle with this question as I support my teachers in being the best they can be for their students. My research will focus on the question: How can inquiry-based instruction be implemented in a secondary mathematics classroom? I hope to
generate tools that support me in my future teaching by exploring how inquiry can best be implemented in a mathematics classroom.

**Summary**

I hope to answer the question: *How can inquiry-based instruction be implemented in a secondary mathematics classroom?* In Chapter One, I outlined how my experiences as a student, teacher, and instructional coach have impacted the way I believe math should be taught. I have learned that beginning teachers draw on their own experiences as a student when forming their own teacher identity. This can create a cycle of didactic methods of teaching that impact student learning and engagement. In Chapter Two, I will define inquiry-based instruction through the lens of teacher and student roles. Additionally, I will explore the benefits and challenges of implementing an inquiry-based framework, and describe how inquiry can be used in a mathematics classroom. In Chapter Three, I will describe the methods I will use to create a framework of inquiry in a secondary mathematics class. Chapter Four will show the results of what I create for inquiry, and Chapter Five will summarize my capstone process, including the limitations of my framework and any future work.
CHAPTER TWO

Literature Review

Introduction

In Chapter One, I discussed the role that my experience as a student had in shaping the way I viewed learning and retained information. Additionally, I discussed the role that an education rooted in transmission of knowledge from teacher to student played in helping me form my own teacher identity during my first year of teaching. Throughout two more years of teaching and two additional years as an instructional coach, I realized that in order for students to learn math in an authentic way, there needed to be drastic changes in the structures of the classroom. Thus, my question became: How can inquiry-based instruction be implemented in a secondary mathematics classroom?

In this chapter, I first examine inquiry-based instruction through its components, the role of the teacher, and the role of the student. Next, I review some of the benefits and challenges of implementing and using inquiry-based instruction in the classroom. Finally, I discuss the ways that inquiry-based instruction can beutilized in a mathematics classroom.

Understanding Inquiry-Based Instruction

In the following section a definition of inquiry-based instruction will be provided. The four phases of inquiry, along with the levels of autonomy of various types of inquiry will be discussed. In understanding the definition of inquiry-based instruction, a critical component is a clear description of the teacher’s role. This section will highlight the importance of facilitation over transmission. Additionally, students play an important role in the definition of inquiry-based instruction. This section describes the role of students and the importance of student interactions and reflections with their peers.
Phases of inquiry-based instruction. At its core, inquiry-based instruction is rooted in the self-construction of learning through active engagement with the environment. Inquiry-based learning is often related to various strategies, including problem-based learning, case method instruction, active learning, activity-based instruction, project-based learning, team-based learning, situated learning, anchored instruction, and discovery learning (Malone, 2008). Deskins (2012) suggests that inquiry moves beyond collecting facts, and instead requires the learner to ask questions, find answers, and create links to previous learning and understandings. Inquiry pulls students away from memorization of content, placing emphasis on the investigation of material.

While the definition of inquiry-based instruction is rooted in the activities that students participate in, it is also described by the skills that students develop as a result of the structure. Kuhlthau, Maniotes, and Caspari (2007) suggest that inquiry supports students in developing an increased understanding of a problem as a result of evaluating multiple sources. It pushes students beyond finding the right answer to make connections between the curriculum and the world around them. They continue by writing, “[Inquiry] espouses investigation, exploration, search, quest, research, pursuit, and study” (p. 2). I, too, have seen that inquiry supports students in building skills of research and exploration. For example, when students were required to develop questions and investigate their understanding on an activity in math, many were able to articulate its application to research for a paper in their language arts class, as well as apply their skills of exploration to activities in science class.

While various models exist under the umbrella of inquiry, the 7E Structure and Stripling Model are commonly used or adapted. The updated 7E model is comprised of seven stages: Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend (Miranda & Hermann, 2012).
The Stripling Model, broken up into six stages, focuses on a similar structure of instructional components: Connect, Wonder, Investigate, Construct, Express, and Reflect (Deskins, 2012). In these, and most other inquiry instructional models, four main components are present: Engage, Explore, Explain, and Extend (Marshall & Horton, 2011). It is important to take a closer look at these four crucial components.

In the Engage stage, a teacher has the opportunity to highlight misconceptions and uncover previous knowledge about the topic being covered (Marshall & Horton, 2011). Teachers attempt to access students’ prior knowledge. In this phase, teachers use short activities to pique students’ interest and build enthusiasm. This excitement should be rooted in connections between what students know and can do, and familiarizing students with the learning goals of the lesson (Piyayodilokchai, Panjaburee, Laosinchai, Ketpichainarong, & Ruenwongsa, 2013).

During the Explore component, students investigate a concept of question through active engagement with a topic (Marshall & Horton, 2011). The importance of exploratory experiences can be explained through the opportunity for students to develop a common set of experiences that call upon present skills and understandings to inevitably impact change in conceptual understanding. The Explore phase provides students with the opportunity to compare thoughts and ideas with peers in order to identify common understandings and illuminate misconceptions. Students may use manipulatives or other resources as they develop new ideas, questions, and investigations (Piyayodilokchai et al., 2013).

The Explain stage provides learners with the opportunity to unite prior knowledge with learning from the current investigation. Within this stage, students should develop a conceptual understanding from the activity as a result of resolving any instability or uncertainty that was generated in the activity. Within this phase, students and teachers have the largest number of
interactions. Teachers may even use direct instruction in order to enhance students’ understandings or elaborate on the academic language associated with students’ learnings. Students’ foci are narrowed onto a specific outcome of the earlier two stages. Within this phase, students are expected to display their conceptual understanding and learned skills (Piyayodilokchai et al., 2013).

Finally, in the Extend component of the model, sometimes called the elaboration phase, students work to deepen their understanding of the content and apply learning to new or previously learned concepts. Students must play an active role and be fully engaged during the Explore and Explain phases. The Explain phase creates space for students to analyze and make sense of the information collected during the Explore phase (Marshall & Horton, 2011). Students may apply their understanding to a new activity, pushing students to develop a deeper understanding of the content (Piyayodilokchai et al., 2013).

Levels of autonomy in inquiry-based instruction. While the components of this framework should be present in all inquiry-based activity, the level of autonomy given to students may vary depending on the objective of the lesson or the intention of the teacher. Levels of autonomy may range from least autonomous, in confirmatory inquiry, to most autonomous, in open inquiry. Variation within inquiry-based instruction models can be described through scale, mode, and framing. The scale of inquiry refers to the ways in which inquiry is used in the planning of a course through to the daily-level activities for each lesson (Sprounken-Smith, Walker, Batchelor, O’Steen, & Angelo, 2012).

The mode within inquiry-based learning refers to and encompasses a spectrum of approaches based on the level of independence granted to students, ranging from structured, teacher-directed approaches to student-directed open inquiry (Zion & Mendelovici, 2012). Four
classifications within this spectrum are confirmatory, structured, guided, and open. These classifications rage from least autonomous in confirmatory inquiry, to most autonomous in open inquiry.

In confirmatory inquiry, students are asked to confirm a previously learned concept or relationship through a teacher-planned question and procedure. This is the least autonomous structure, as students are asked to confirm knowledge that they already possess (Whitworth, Maeng, & Bell, 2013).

Structured inquiry provides more autonomy than confirmatory inquiry, yet students are still participating in teacher-planned processes. In this category of inquiry, students are given step-by-step instructions at each stage of the activity. The teacher presents the students with a question and students follow guidelines to reach a pre-determined outcome. As the teacher predetermines the questions, processes, and outcomes, there is far less autonomy in this process. Students work hands-on with content and the emphasis is placed less on building autonomous thinking skills, and more on building connections between evidence and ideas. Structured inquiry, then, is used as a way of developing the baseline inquiry skills that can serve as a foundation to build upon (Zion & Mendelovici, 2012). In my experience, I have found students are most comfortable with structured inquiry, as it provides clear guidelines to follow and a clear definition of success. In my own implementation of this structure, I have seen students make connections between these procedures and following a recipe, something many of my students were familiar with.

Guided inquiry describes an experience in which students explore a question and procedure developed by the teacher. Guided inquiry provides students with a more autonomous experience than structured inquiry, as students then work collaboratively to determine the
processes to be used and the targeted outcomes. Guided inquiry creates the opportunity for a lower level of uncertainty throughout the inquiry process, as students are given inquiry questions and procedures, and results in more autonomy in student decision making and activity outcomes (Zion & Mendelovici, 2012).

Open inquiry is the most complex and autonomous of all inquiry-based structures. Teachers solely provide students with the framework of learning for the activity. Students, then, select an inquiry question from a pre-generated list or create their own question. The procedures and outcomes are determined by the students through collaboration with peers. Open inquiry relies heavily on teacher facilitation and the ability of the teacher to guide students throughout the process. Student participation and development of a challenging, relevant inquiry question is at the core of open inquiry, making it the most autonomous process for students (Zion & Mendelovici, 2012). Without previous student exposure to the inquiry framework, I have found that this structure is the most challenging to implement in a classroom. For example, in my work with a math teacher to implement an open inquiry structure, she encountered many challenges in student behavior as a result of many students lacking the confidence to engage in the activity without her support.

Spronken-Smith, Walker, Batchelor, O’Steen, & Angelo (2012) describe the responsibilities of students to “formulate the questions themselves as well as going through the full inquiry cycle (e.g. engage with a topic, develop a question, identify what needs to be known, collect and analyse [sic] data, synthesise [sic] findings, communicate results and evaluate the research” (p. 58). The framing of inquiry-based learning focuses on two main orientations: discovery-oriented and information-oriented. In an inquiry structure, students learn content and experience understanding through exposure to new questions and the expectation of questioning,
exploring, and discovering. In traditional, transmission structures, when students conduct research, they often seek pre-existing answers and are prevented from encountering novel bodies of knowledge (Spronken-Smith, Walker, Batchelor, O’Steen, & Angelo, 2012). Despite variations in inquiry-based models, the underlying focus on student-level construction of knowledge and teacher facilitation is consistently present.

The role of the teacher. Successful implementation of an inquiry-based instructional model is dependent on the ability for a teacher to facilitate student exploration. A teacher must take on the role of facilitator, supporting students by probing, questioning, and assisting in the process of combining pieces of learning cohesively (Marshall & Horton, 2011). Inquiry, then, is defined through students actively seeking to understand and learn new material through the activation of previously learned content, supported by the guiding forces of the instructor.

Crawford (2000) explored the mindsets and actions of a teacher who had successfully and consistently used an inquiry-based model. Crawford suggests that the roles of teacher and student in an inquiry setting are complex and often change, creating multiple roles that each must play throughout the lesson. Teachers must view inquiry through both lenses of content and pedagogy in effective implementation of inquiry-based instruction, generating additional roles in order to support students’ mastery of content and the development of essential skills for long-term learning.

Crawford identified 10 roles that were essential for the teacher to take on while utilizing an inquiry-based model, as follows:

- Motivator
- Diagnostician
- Guide
• Innovator
• Experimenter
• Researcher
• Modeler
• Mentor
• Collaborator
• Learner

These roles push beyond identifying the teacher as the guide in the classroom. I have found that the roles of motivator and modeler are most important in supporting students as they learn about the inquiry framework. Playing the role of motivator, in my experience, requires a commitment to pushing students to be perseverant in the face of the challenges and obstacles that often arise in the inquiry framework. Additionally, in my experience, playing the role of modeler provides students with the opportunity to see the processes and thoughts that are involved in questioning and exploring content, as well as overcoming challenges. I believe it is the responsibility of the teacher in an inquiry-based lesson, and in all lessons, to effectively model overcoming challenges and share a belief in students potential to do the same. This will help ensure that students are better set up for success in future lessons, and support students in developing the habits, skills, and mindsets of strong life-long learners.

Marshall and Horton (2011) describe the role of the teacher as the facilitator of discussions and explorations that support students in analyzing information and formulating new ideas, rather than simply recalling or listing facts. While a student-centered classroom places most of the power in the hands of students, a teacher who can effectively engage students in this process is vital to the success of inquiry in any classroom. Estes (2004) highlights this
requirement by suggesting that teaching inquiry can only be successful if a teacher has the knowledge and skills required to initiate and sustain conversations about students' experiences and learning. She continues by writing, “Most experiential educators…have been socialized and educated in traditional teacher-centered venues. Thus, we are comfortable with students looking to teachers for information, answers, guidance, affirmation, and permission to speak” (p. 153). In order to effectively implement an inquiry-based model, a teacher must discern the differences between her own education and the one she desires to present to students.

As previously mentioned, inquiry must be an active process in which students are engaged in the material and working to construct a meaning of the content in a way that is relevant to their lives. Inquiry-based instruction, then, requires a strong culture that is centered on the ability to make mistakes and learn from the collective effort of the group. A teacher’s role is to share important information, but also to shape the culture of the classroom so that multiple ideas and perspectives are valued and shared (Cole & Wasburn-Moses, 2010). As is true in any classroom, culture and a sense of security are essential to the success of all students in mathematics. In the same note, students must be willing to make mistakes and support one another in the search for understanding. The teacher’s role is to serve as a guide, pushing students to rely on one another and their understanding of the essential information. Thus, an effective inquiry-based classroom is extremely dependent on the effectiveness of the teacher.

Marshall and Horton (2011) state that “Successful facilitation of inquiry-based instruction necessitates a shift from either of two extremes…an activity mania in which students are kept occupied but only at superficial levels or teacher-dominated lecture in which instructors try to pour knowledge into their students’ heads” (p. 94). This idea draws on the need for activities to be designed around a single concept. While students should be encouraged to dive
deeply into the material they are discovering, it is equally important to ensure that the activities
that students are completing are meaningful in aiding them in uncovering new knowledge.

Creating a safe space for learning and taking risks is only one component of the teacher’s
role. Additionally, the teachers must be aware of the cognitive abilities of his/her students in
order to effectively guide students to ask and explore challenging questions (Zion &
Mendelovici, 2012). The teacher aims to guide students through the developments of critical
thinking and problem solving skills while pushing them to engage in higher-level thinking, along
with building motivation for learning. This can only be possible if a teacher has a strong
understanding of her students’ abilities, as well as how students construct new knowledge
(Tseng, Tuan, & Chin, 2012). Students’ current understandings and experiences brought into the
lesson serve as a starting place for the teachers questioning. Their theories and understandings
may be incorrect or incomplete, and a teacher’s questioning must begin challenging
discrepancies to build a learning environment that is relevant and beneficial to students
(Kotulakova, 2013). This notion illuminates the idea that students, additionally, play a large role
in creating a successful inquiry-based model.

The role of the student. As a student-centered model, inquiry creates a space
where much of the power in the classroom belongs to students (Estes, 2004). While this
definition describes all student-centered models, it adequately describes inquiry-based
instruction, as students must learn the skills of questioning and finding answers using evidence
(Deskins, 2012). Thus, an inquiry model provides students with more power, requiring each
student to claim ownership of his or her learning through the pursuit of knowledge. By watching
a teacher model through lecture, students are not able to generate a personal understanding of the
content and, instead, mimic strategies and procedures (Johnson & Norris, 2006). Students must
work with their peers and hear how others comprehend content, as well as how other students problem solve in various scenarios. While students may have mirrored understandings or tendencies in problem solving, students must also recognize that each understanding is personal and valid, as it is constructed in a way that complements the learner (Johnson & Norris, 2006).

When students are confronted with something new, they rely on earlier experiences to begin to make sense of the new information. As students hear their peers attempt to explain new experiences, modifications to the students’ original attempt at understanding occur. The student is then responsible for generating and testing a prediction about the new information. This process of using experiences to generate and experiment with predictions is at the core of the student’s responsibility in inquiry-based learning (Kotulakova, 2006).

Students must be taught how to use the skills associated with inquiry-based instruction and must challenge themselves to implement inquiry-aligned strategies throughout the learning process. Armed with knowledge of what skills are available, students can begin to decipher when it is appropriate and effective to use them (Deskins, 2012). Specific skills must be utilized in an inquiry-based model. Students must pursue questions, ensuring that they do not know the answer to the question before they begin. They must make predictions rooted in their own ideas and must take part in planning and executing the process for investigating the prediction. Students must keep notes during their work and discuss their methods and findings in terms of their initial predictions. Finally, students must draw conclusions and compare their findings to the conclusions of their peers (Harlen, 2013).

Conclusion. Inquiry-based models require a student-centered atmosphere in which both teachers and students are accountable and active members of the learning community. Various structures exist within the framework of inquiry broken, most characterized by four phases:
Engage, Explore, Explain, and Extend. Additionally, structures of inquire can be characterized by the level of autonomy granted to students, ranging from least autonomous in confirmatory inquiry, to most autonomous in open inquiry.

Both teacher and student play an important role in successful inquiry. Teachers most must take on many roles throughout the process of inquiry, focusing on serving as a facilitator and guide for student learning. Students play a crucial role, as their participation, their prior knowledge, and construction of a personal understanding are at the core of the inquiry model. In the next section, the benefits and challenges of inquiry-based instruction are explored.

Benefits and Challenges of Inquiry-Based Instruction

The following section will describe some of the potential benefits and challenges in the implementation and continued use of an inquiry-based framework. Benefits of inquiry-based instruction are mostly rooted in the skills and mindsets that students develop throughout the process of learning, as well as the ability for students to apply learnings to the real world. Challenges of inquiry-based instruction will be discussed and often result from teacher and student unfamiliarity with the structures of this framework. This unfamiliarity can result from student discomfort with a change in expectations, and can be rooted in teacher preparation or understanding of power dynamics in the classroom.

Benefits of inquiry-based instruction. Many of the benefits that result from an inquiry-based instructional model are rooted in the development of skills and mindsets in students, supporting them in becoming better life-long learners and, thus, better citizens. Some examples of these benefits are student motivation and investment, a deepened understanding of content, and the development of critical thinking skills.
Benefits of inquiry-based instruction are often generated in comparison to that of the traditional classroom setting. In this case, the traditional classroom setting refers to a lecture-based, teacher-centered classroom where the teacher serves as the keeper of information and works to share this information with students. In comparison with the didactic methods of traditional teaching where students’ primarily listen and read, inquiry-based instruction is learner centered, providing students with the opportunity to use and think critically about information. Additionally, students are asked to explore and create their own solutions, communicating their thinking in oral and written forms (Malone, 2008). This distinction between the two frameworks for teaching illuminates the many benefits of the inquiry-based model.

Inquiry-based instruction, in comparison with traditional, didactic instructional strategies, has been shown to more likely promote acquisition, retention, and the transfer of knowledge. As traditional instruction focuses on the development of inert knowledge, it is not oriented towards the development of critical thinking and problem solving. Furthermore, this orientation can negatively impact a learner’s motivation for learning new information (Malone, 2008). I too have noticed the impact of teacher-centered, lecture-based learning environments on my students’ investment in engaging with content and pushing beyond the foundational components of content to a deeper conceptual understanding.

Inquiry-based instruction moves beyond the basic knowledge of content, into the qualitative aspects of the learning process. Malone, 2008, identifies the following benefits of the inquiry-based model:

- Increased self-awareness
- Ownership
- Personal responsibility
• Promotion of critical thinking
• Enhanced self-efficacy, confidence, and independence
• Increased motivation/interest
• Integration of existing perceptions with experience
• Acquisition, retention, and transfer of knowledge
• Adaptation of instruction to learner rather than forcing learner to fit instruction
• Alignment with Bloom’s Taxonomy
• Promotion of significant learning
• Support of basic human needs including competence, choice, enjoyment
• Development of writing and research skills
• Support of an orientation toward learning and mastery

Although each benefit is important, the following paragraphs will explore increased motivation/interest, promotion of significant learning, and promotion of critical thinking, as these are three benefits I find most important in building strong life-long learners.

Learning through an inquiry-based framework can serve the interests of individual learners, as it supports them in developing the knowledge and skills to build connections between the content they learn in class and the world around them. These connections stimulate interest in learning the content, as students’ learning becomes more familiar, relevant, and applicable outside of the classroom (Harlen, 2013). Developing connections between the real world and the classroom drive students’ desire to explore and understand more about the world. Harlen (2013) suggests this benefit balances satisfaction and inquisitiveness about the world around students. As material becomes more relevant, students discover that work is not “busy
work,” and is instead relevant and essential to the learning process and success in the classroom (Laursen, Hassi, Kogan & Weston, 2014)

Student investment and motivation may additionally be rooted in the types of activities that students participate in as a result of the inquiry-based framework. Harlen (2013) relates inquiry-based activities to student investment because students often feel joy and satisfaction in the act of discovering new, interesting knowledge on their own. Successful inquiry-based frameworks create space for students to be involved in the thinking and exploring, impacting student motivation through ownership of process and learning (Fitzgerald & Byers, 2002). Examples of inquiry-based activities are rooted in collaborative group work and discussion, as well as a focus on student-generated content as an essential component of solving real-world and cross-disciplinary problems that they feel responsible for (Gonzalez, 2013). In my experience, as Gonzalez references, students are often more motivated by the ability to work in small groups and bring in their own experiences, as makes content more accessible and engaging.

An additional benefit of using an inquiry-based framework is the promotion of significant learning. Marshall & Horton (2011) suggest that an inquiry-based framework moves away from rote learning and places importance on the development of deep conceptual understanding. Much of this depth can be attributed to the processes students go through during an inquiry-based lesson. Gonzalez (2013) suggests that students produce stronger work as a result of developing stronger research, reasoning, writing, and presentation skills. This growth in student work and, in turn, the growth in student learning is rooted in the challenging process of interrogation.

Gonzalez (2013) describes this process of interrogation as, “weighing evidence, critiquing sources, examining counter-arguments, and, usually, constructing limited, highly
provisional arguments, much as scholars do” (p. 37). As student learning mimics the actions of scholars, students move closer and closer to becoming experts in the content.

As a result of using an inquiry-based framework, students may develop stronger critical thinking skills. In my experience, the development of strong critical thinking skills is powerful, as these skills transcend the classroom walls and impact the way that students interact with the world around them. The Organization for Economic Co-Operation and Development (OECD) (1999) suggests that, during the school day, students do not have the opportunity to learn all of the information and skills that they will need in their lives. Thus, it is essential that students learn the skills that are required for successful future learning. While involved in an inquiry-based classroom, students have the opportunity to regulate their own learning independently and collaboratively, and develop the skills to overcome difficult challenges in the learning process (OECD, 1999).

In developing strong critical thinking skills, we better prepare students to operate within our democratic society (Gonzalez, 2013). Gonzalez (2013) suggests that teachers must support students in fulfilling a democratic mission by supporting students in developing the skills of acquiring and sharing their own knowledge. In order for this mission to be achieved, students must become strong questioners, rather than just developing skills around finding the right answer. The spirit of the inquiry-based method supports students in developing stronger critical thinking skills and supports them in solving complex problems, making them stronger members of our society and more likely to excel in the future (Marshall & Horton, 2011).

Some of the benefits that occur as a result of using an inquiry-based model have been identified. Next, some of the challenges that instructors and students may face while implementing an inquiry-based instructional framework are explored.
**Challenges of inquiry-based instruction.** Many of the challenges that arise when implementing an inquiry-based model are rooted in the transition for students and teachers. As both parties’ experiences with education most often align with the traditional models of a classroom, as teachers and students learn to be successful in an inquiry-based model, challenges may arise. Some of the difficulties that arise while implementing an inquiry-based model are teacher preparedness, teachers’ fear of losing control of classrooms, and student frustration (Bunterm et al., 2014).

The challenges that may arise for teachers are rooted in a lack of understanding or training in how to successfully implement an inquiry-based model. Donnelly, McGarr & O'Reilly (2014) suggest that this unawareness in rooted in a lack of understanding of the roles teachers and students play in a traditional setting and the implications for learning in that environment as a result of this power dynamic. In not fully understanding the impact of the traditional setting, teachers may then struggle with the transition to a new, different model of teaching and learning. Zion et al. (2004) suggest that the most significant factor influencing successful implementation of an inquiry-based framework is teachers’ knowledge. Thus, without providing teachers with the necessary knowledge to develop and implement an inquiry-based framework, it is not possible for students to experience the benefit of its implementation.

This struggle is especially present in a setting where a specific answer is to be reached by students. Furtak (2005) explains that a guided inquiry structure can be one of the most challenging settings when teachers are ill-equipped to support students in the learning process. As teaching settings often require the identification of a specific answer, teachers have not received the support necessary to learn the skills of properly supporting students in finding their own answer. As a result, teachers often struggle with the act of withholding answers when
students are struggling to reach them. This struggle may also impact the way that students perceive the learning environment.

During pre-service, teachers attend methods and teacher preparation courses. Multiple studies have shown that, regardless of participation in coursework aligned with constructivist learning theory, teacher candidates struggle to implement the instructional strategies that support inquiry-based learning in classrooms (Meyer, 2004). I, too, have seen the challenge of implementing inquiry-based strategies, especially within my first year of teaching. Much of this challenge was rooted in my lack of experience with an inquiry-based model in my own education. The model I was building my own teaching structure on was that of the traditional model, as each of my teachers in my own education had used this model.

Management of an inquiry-based classroom may be a challenge for a teacher implementing this framework. As students become more independent, the class may become less structured, especially in comparison with the traditional model. A teacher must be confident in their implementation to ensure that they do not experience the challenge of losing control of the classroom. Zion and Mendelovici (2012) suggest teacher confidence is one of the most critical components of successful implementation of an inquiry-based framework because of the importance of a teacher’s role in student learning. If a teacher lacks confidence, a space for productive inquiry may not be produced.

More generally, studies have shown that teachers struggle to maintain an atmosphere that engages and encourages students to participate in student-directed inquiry, especially within a guided inquiry model (Sadeh & Zion, 2009). This struggle can potentially be rooted in the teachers struggle to release control to students as they build their independence. Teachers may become fearful and anxious as a result of teaching inquiry. These reactions may stem from the
transition to a student-centered approach from a teacher-centered approach, as teachers may not be used to releasing control to students (Spronken-Smith et al., 2011).

Challenges may also be student-facing, as students may also struggle with the transition to an inquiry-based learning model. As the structure of the classroom moves towards a community model, teachers must support students in the process of knowledge construction, something that is often challenging to do (McDonald & Songer, 2008). As tasks become challenging, student investment and motivation may be greatly impacted. In order for inquiry-based learning to be implemented successfully, students are confronted with challenging, authentic problems. In order to solve these problems, students must be willing to take risks, something that is challenging, especially in an unfamiliar learning structure (Sadeh & Zion, 2009).

Similarly to the tendencies of teachers, students, especially younger students, do not automatically use the skills and processes associated with inquiry, as many of them are used to the didactic, traditional model (Harlen, 2013). This is especially true for students who are asked to work in groups for the first time. Students may be unsure of the new expectations in the inquiry-based model as they are asked to become more responsible for their own learning. Students experiences can be related to that of the teacher, as students can also experience components of the ‘grief curve’, especially when they are faced with challenges and are forces to make decisions about processes and procedures (Spronken-Smith et al., 2011). This grief curve can impact the way that students are invested and motivated in the inquiry-based model.

Research suggests there are many benefits of using an inquiry-based model in the classroom, and despite this, challenges may arise as a result of the transition from a traditional, didactic setting. Student learning and motivation can be positively impacted if an inquiry-based
model is implemented with the proper supports. In the next section, inquiry-based instruction will be described through the lens of a mathematics classroom.

**Inquiry-based Instruction in a Mathematics Classroom**

*The Final Report of the National Mathematics Advisory Panel* highlights the need for students to develop strong mathematics skills as a way to preserve national economic competitiveness and to ensure that more doors are open for all students (U.S. Department of Education, 2008). Proclaiming that the system by which students transform mathematical knowledge into significance and ability is broken and requires fixing, the U.S. Department of Education’s (2008) push for change is supported by recent research that highlights the challenges faced by students in math classes. The typical classroom has remained static for the past two generations. These classrooms place most of the responsibility of thinking on the teacher, providing students with the task of memorization. A typical mathematics class follows a daily routine of reviewing the material and homework from the previous day, a component of the teacher modeling lower-level problem solving, and a conclusion of evaluating answers and a homework assignment (Stonewater, 2005).

In a recent study of eighth graders, only 32% of students were at or above proficient in mathematics (Cole & Wasburn-Moses, 2010). The combination of poor student performance and the need for opportunity has highlighted the urgent need for a reevaluation of the way that mathematics is being taught in classrooms across the nation. The push toward inquiry is rooted in the potential to lead to the understanding and attitudes that are needed for students to be successful in life (Harlen, 2013).

The focus of student ownership and investigation is essential in defining the inquiry instructional model in the context of a mathematics classroom. In extending the concept of
inquiry to a mathematics classroom, students are expected to develop an understanding of traditional math rules in a conceptual light. Students can do this through group work and solving problems that require the application of various skills, rooted in application to the real-world (Cole and Wasburn-Moses, 2010).

Traditional, teacher-centered classrooms do not necessarily promote group work and create opportunities for students to work with their peers in order to build an individualized understanding of a concept, whereas student voice plays a defining role in the success of an inquiry-based model. The goals of this model are to focus on active engagement by students as well as an exposure to higher-level mathematical thinking. Inquiry must be an active process in which students are engaged in the material and working to construct a meaning of the content in a way that is relevant to their lives (Cole & Washburn-Moses, 2010).

Inquiry in mathematics, then, must be rooted in higher-level thinking. These higher-level demands deviate from the memorization of math facts and using algorithms without understanding the underlying concept, to building connections, representing thinking in multiple ways, and the development of new, more complex skills for problem solving (Cole & Wasburn-Moses, 2010).

The National Council of Teachers of Mathematics (NCTM) has used the fundamental concepts of inquiry to introduce process strands used for all grade levels: problem solving, reasoning and proof, communication, connections, and representation. In developing these strands, NCTM stresses the importance of building student learning that is rooted in understanding the interconnectedness of mathematical concepts and producing a more coherent, holistic understanding of mathematics. This is supported through the use of various representations to solve problems, and making content applicable to many contexts (Johnson &
Norris, 2006). NCTM has recognized programs that are constructed based on the standards described earlier. Programs such as Connected Mathematics, Mathematics in Context, MathScape, and MATH Thematics use a discovery model to build student understanding (Johnson & Norris, 2006).

This structure suggests that the typical math classroom should make room for students to explain their thinking and reasoning to their classmates on a daily basis. Johnson & Norris (2006) justify this need by writing, “when students listen to others, they develop their own understandings by enlarging their knowledge base, adding to their repertoire of problem-solving strategies, or expanding their understanding of mathematical relationships” (p. 9). By expecting students to claim ownership of their learning and by creating opportunities for material to be accessible by all students in a classroom, inquiry-based instruction stresses high expectations for all students (Johnson & Norris, 2006).

While many components of inquiry in mathematics mirror the use of inquiry in other content areas, specific requirements arise as a result of the nature of mathematics. These differences relate specifically to the questions or problems students are attempting to solve and how solutions are expressed (Harlen, 2013). In each of these areas, the nature of mathematics plays a role in the way inquiry-based pedagogy can be used.

First, as teachers generate questions and problems for students to solve, they should choose problems that come from the real-world. In mathematics classrooms, inquiry-based questions can also arise in abstract constructions such as numbers, shapes and algebraic structures. An example of a problem generated from the real world would be how to measure a very large building or other object (Harlen, 2013). An inquiry starting from mathematics itself would be asking students to determine the greatest product that can be obtained by decomposing
a positive integer into a sum of positive integers and multiplying the terms of the sum. (Harlen, 2013).

As students navigate questions arising from real life, it is also important to ensure that the questions being asked are solvable within the realm of mathematics. This way, as students generate solutions, especially with regard to problems generated from the real-world, students can use a process of modeling that is specific to mathematics. Harlen (2013) describes modeling as conceptual or physical representations used to describe relationships, mimic events, or generate explanations for specific scenarios. Students may then make connections between the solution generated in the model and more complex scenarios in the real-world.

Summary

Inquiry-based instruction refers to a style of pedagogy in which students take on the role of investigation and creation of understanding, rather than learning through transmission of knowledge from teacher to student. An inquiry-based framework requires students to participate in at least four stages of a lesson: Engage, Explore, Explain, and Extend. Additionally, the level of autonomy and independence students are granted can range from confirming information given by the teacher in confirmatory inquiry to student-generated questioning in an open inquiry structure. The teacher, in each case, takes on the role of facilitator and guide, releasing more control and to students. The students, then, take on the role of explorer and participate in discussion and discovery with their peers throughout the inquiry-based lesson.

There are many benefits as well as potential challenges that may arise from using an inquiry model. Benefits from using an inquiry model include, but are not limited to, increased student motivation, self-awareness, motivation, learning, and retention. Challenges may arise due
to lack of teacher preparation, management of a classroom with less teacher-centeredness, and student hesitation and unfamiliarity with the new structures for learning.

A movement towards the use of inquiry-based instruction in mathematics has arisen as a result of the need for new methods that increase student understanding and retention of content. Inquiry in mathematics requires students and teachers to focus on higher-level thinking, moving away from procedural recall and a focus on math facts. An inquiry-based mathematics classroom must create space for students to work with their peers daily and make connections between class and the real-world.

Within my experiences as a student, teacher, and coach I have experienced the importance and impact of learning in an inquiry-based model. My mission within my education was to acquire as much knowledge and develop as many skills as possible. Motivation and ownership of learning are skills that I developed throughout my educational experience, and I have myself develop them most quickly in settings that pushed me to challenge myself and apply my learning to something beyond my classroom. I believe that the inquiry-based learning framework provides students with the opportunity to not only develop a deep understanding of mathematical content, but more importantly supports students in becoming stronger leaders and citizens that ask questions, rather than just look for correct answers.

In Chapter Three, I will discuss the methods I will use to answer my research question. I will identify the tools that must be created in order to support the implementation of an inquiry-based framework in a secondary mathematics classroom.
CHAPTER THREE

Methods

Introduction

I am exploring the question: How can inquiry-based instruction be implemented in a secondary mathematics classroom? This question is important to me because I have observed a trend in increased student learning as students are moved to the center of the classroom, rather than the teacher. Additionally, as I reenter the classroom next year, I want to ensure I have a structured framework that will support the implementation of inquiry in my secondary mathematics classroom.

Inquiry-based instruction is focused on student-centered learning, giving students the opportunity to create an individualized understanding of new material, while also rooting it in prior knowledge. In this setting, the teacher serves as the facilitator and guide, while students rely on interactions with peers and exploration of content to drive their learning. In a mathematics classroom, student learning moves away from rote, procedural understanding, and focuses on a higher-level conceptual understanding of content.

In this chapter, I will discuss the setting and participants of my curriculum creation. Next, I will outline the methods I will use to explore my question. Additionally, I will describe the tools I created in order to build a framework for implementing inquiry-based pedagogy in a secondary mathematics classroom.

Setting

This curriculum is being created as a tool to support learning in a secondary mathematics classroom, with specific focus on urban, public school settings. As I transition from a role in teacher support back to the classroom, my intention is to work in a secondary mathematics
classroom in an urban school setting and use the curriculum I create to implement inquiry-based instruction in my own classroom. The following paragraph describes a typical urban school setting in order to anticipate the setting I will be using this curriculum in.

A typical urban school is comprised of the following racial demographics: 34.9% Hispanic, 29.7% White, 24.8% Black, 6.7% Asian, 2.7% Mixed Race, 0.8% American Indian/Alaska Native Describe, and 0.4% Pacific Islander. Additionally, in a typical urban school, 11.6% of students have Individual Education Programs (IEPs) and 15.1% of students are limited-English proficient. A typical urban public school also has a large proportion of students qualify for free or reduced-price lunch, as 62% of urban schools nationwide have at least 50% of students qualify (Institute of Education Sciences, 2011). While these descriptions may not be identical to those of the school I will teach in next year, they describe an approximation of the setting I will be implementing my curriculum in next year.

Participants

This curriculum will be designed for use in a secondary mathematics classroom, with the intention of having the tools be applicable to any subject area and topic within mathematics. As I anticipate working in an urban setting, the following information describes typical characteristics of urban youth, as well as information supporting the using of inquiry in an urban setting.

Students in urban schools are often exposed to zero-tolerance discipline policies and gentrification of communities of color. As a result, urban schools often devalue the views and values and express misalignment with the way that students, especially students of color, understand the world (Stovall and Delgado, 2009, p. 67). Foote & Bartell (2011) write, “Currently, mathematics education generates selection, exclusion and segregation of students along the lines of gender, race, language, and socioeconomic status” (p. 45). As I interact with
students who interact with this divide regularly in math classrooms, it will be important for me to think about how these experiences shape the way students are perceiving the class and their learning. In my experiences as a teacher, many of my students entered my classroom with a negative perception of math. After giving surveys to my students, I found that the vast majority had not experienced success in math and, as a result, did not believe they were capable of being successful in my class. I anticipate that this experience is not unique to my previous three years of teaching. As I implement this framework, it will be important to continually understand students’ mindsets and support students in developing a strong belief in their potential.

**Methods**

In order to answer my research question, “How can inquiry-based instruction be implemented in a secondary mathematics classroom?,” I generated a set of tools that can be used to support successful implementation of an inquiry-based model. As I plan to reenter the classroom as a secondary mathematics teacher, I want to ensure I am providing my students with an inquiry-based learning environment. As I am not aware of the age level or subject area I will be teaching, I want to ensure that the tools I create will be useful in any secondary mathematics classroom. The following tools have been generated as components of my framework. The tools I created are a lesson plan template, an introductory lesson, a gradual release timeline, a classroom layout, a description of classroom accessories, assessment resources, a guide for the use of technology, a bibliography of resources, and a reflection log.

**Lesson planning template.** As a means of ensuring that each component of the inquiry process is incorporated into each daily lesson, I created a lesson planning template that can be used by classroom teachers during the planning process. While ensuring that stages of the
inquiry model are present in each lesson, the lesson planning template also provides space for a teacher to plan for differentiation within the lesson.

**Introductory lesson.** In order to show how the lesson planning template will be used, I created a model lesson within the template to be used at the beginning of the school year. Along with providing an exemplar for use of the template, this tool also serves as an introductory lesson to be used at the start of the school year in order to build student knowledge and understanding of what inquiry is and how it will be used in class. This transparency with students will be helpful in supporting students who have not been exposed to an inquiry model in previous mathematics classes. This lesson will use familiar and engaging content so that the model of inquiry is more accessible for all students.

**Scope and sequence/gradual release framework.** As many students will need support in building familiarity within the inquiry model, I created a model for the school year with suggested components of inquiry to focus on. Additionally, this model supports teachers in determining the appropriate level of autonomy and independence throughout the school year to push students toward developing the skills and mindsets required in open inquiry. This tool will be helpful because I have encountered resistance and nervousness from students when faced with an open inquiry structure without exposure to formats with less autonomy. Thus, this tool will focus on gradually releasing students into open inquiry throughout the year.

**Classroom layout and seating arrangements.** I created a diagram and supporting documents to describe the optimal classroom layout and seating arrangements for students. As collaboration and classroom culture are important components of a successful inquiry classroom, this tool works to support teachers in creating the optimal classroom layout.
**Classroom accessories for inquiry learning.** This tool identifies supporting accessories that have the potential to support students and teachers in an inquiry model. This tool describes anchor charts, visual supports, and other resources that can support students in building independence in class.

**Assessment/rubric.** In order to build student and teacher accountability for the knowledge and skills that students need to develop in class, it is important to generate a form of assessment for the use of inquiry within the classroom. While summative assessment may still align with teacher-centered, traditional models, evaluating a student on their use of inquiry is essential for providing feedback and supporting students in becoming stronger learners. I created a rubric that allows for student and teacher reflection on student proficiency in the use on inquiry.

**Technology guidance to enhance inquiry learning.** I generated a tool that outlines the use of technology as a means of enhancing student learning within the inquiry model. As inquiry supports learners in developing the skills they will need to be successful in the future, technology use supports in this preparation. Additionally, effective implementation of inquiry requires the student research, which can be supported through the use of technology.

**Bibliography of resources for inquiry learning.** This tool contains additional resources to support teachers in implementation, as well as, supporting students in building the knowledge and skills of inquiry through reading. As part of my role this year is teacher development, I believe this resource supports me in continuing to share information with colleagues, or supports me in additional staff development in future roles.

**Reflection log.** Throughout the process of developing each tool, I kept a reflection log about things that were exciting and challenging for me. This log created space for me to identify specific opportunities of challenges that may arise in the use of each tool in the future. As I do
not yet know the students I will be working with next year, this reflection log will help me identify areas where I need to learn more about my students before I can successfully implement my inquiry framework.

Summary

In order to answer my research question, *How can inquiry-based instruction be implemented in a secondary mathematics classroom?*, I have generated a set of tools that support the incorporation of inquiry-based instruction in a math class. The tools I created are a lesson plan template, an introductory lesson, a gradual release timeline, a classroom layout, a description of classroom accessories, assessment resources, a guide for the use of technology, a bibliography of resources, and a reflection log. I anticipate that each tool will play a critical role in successful implementation of an inquiry-based curriculum. In Chapter Four, I will show the tools I have created and share reflections I have generated throughout the process.
CHAPTER FOUR

Results

Introduction

The question I am exploring is: How can inquiry-based instruction be implemented in a secondary mathematics classroom? I have chosen this question because I often questioned the structures I had encountered in my own math classes as a student, and continued to explore the impact of a structure on student learning throughout my experiences as a teacher and instructional coach.

Inquiry-based instruction is rooted in student ownership of learning and the opportunity to build new learning atop prior knowledge through hands-on, critical exploration of content. This structure removes the teacher from the center of the classroom and requires students to work collaboratively with peers. This deviates from the traditional mathematics classroom, by requiring students to engage with content, rather than learning through rote procedures.

I seek to develop tools and resources that support teachers in implementing an inquiry-based framework in a secondary mathematics classroom. The tools I created are a lesson planning template, a sample introductory lesson, a scope and sequence for the gradual release of inquiry, classroom layout resources, classroom accessory resources, assessments for inquiry, a technology guide, and a bibliography of resources for teachers. Throughout the process of creation, I recorded my thoughts about the process in a reflection log.

In this chapter, each tool will be presented and a description of the components of each tool will be shared. This chapter will highlight the decisions made in the creation of a lesson planning template, a sample introductory lesson, a scope and sequence for the gradual release of inquiry, classroom layout resources, classroom accessory resources, assessments for inquiry, a
technology guide, and a bibliography of resources for teachers, many of which are rooted in the need to develop the skills and mindsets associated with strong long-term learners.

**Lesson Planning Template.**

The lesson planning template (Appendix A) is created to include essential components of lesson planning with the addition of planning for each stage of the four phases of inquiry described in Chapter Two: Engage, Explore, Explain, and Extend. Effective curriculum planning must be completed backward from long-term desired results to ensure that lessons do not become activity-oriented with no clear objectives or priorities (Wiggins and McTighe, 2005). As a result, this lesson plan contains a space to record big ideas and essential questions to ensure the lesson is rooted in long-term goals. Additionally, teachers are asked to reflect on the assessment for the lesson first, rather than entering into the activities to build upon the necessity for clear objectives and results.

The assessment component of the lesson plan is broken into two parts: content and inquiry mindsets and skills. Assessments must gauge student progress in achieving conceptual understanding of math content, abilities and skills to perform inquiry, and the understandings and mindsets about inquiry (Olson & Loucks-Horsley, 2000). Additionally, formative and summative assessments are necessary throughout all parts of lesson. Throughout an inquiry-based lesson, formative assessment is used more frequently than summative assessment, as students are required to assess their progress and understanding as they explore the content and explain their understanding (Clark, 2014).

The next sections of the template require teachers to develop a plan for each phase of the inquiry process. The role of the Engage phase is to support students in activating prior knowledge, as well as supporting students in becoming invested in the lesson investigations.
(Piyayodilokchais, 2013). The Engage section of the template, then, asks the teacher to determine the prior knowledge that is necessary for student success in the lesson and then determine an activity that allows students to access this knowledge and build investment in the lesson.

The Explore phase provides students with the opportunity to generate and/or explore a question by collaborating with peers through experimentation, research, and discussion (Piyayodilokchais, 2013). Thus, the lesson planning template requires teachers to reflect on guiding questions for the activity, as well as potential questions to support students in the exploration process. Additionally, the teacher is required to develop an activity that supports exploration and collaboration. Finally, once the teacher has developed an activity, she must reflect on the materials and technology needed to complete the activity.

During the Explain phase, students are asked to synthesize their thinking and draw conclusions from their exploration. Additionally, students must communicate their findings with the teacher and their peers (Piyayodilokchais, 2013). The lesson planning template asks the teacher to determine how students will communicate their results and conclusions during this phase of inquiry. An important part of inquiry is developing the language to communicate ideas (Harlen, 2013). The template requires the teacher to identify academic language that students will need to develop in order to provide a strong academic explanation of their conclusions and understanding of the content.

The final phase, Extend, requires students to apply their learnings to a new scenario or new question. This is also the opportunity for students to draw stronger connections between their learning in the classroom and the real world (Piyayodilokchais, 2013). In the lesson
planning template, the teacher is asked to develop an activity that extends the learning process to a new scenario and consider opportunities to build connections to the real world.

The last component of the lesson planning template focuses on differentiation in the lesson. Differentiation is the component of planning that addresses differences in students’ learning needs. In order to determine individual learning needs, teachers must first identify individual readiness, or the student's current level of skills and knowledge, learning profile, or the student’s gender, culture, learning style, and intelligence preference, and the student’s interests, or the topics and ideas that generate curiosity (Whitworth, Maeng, & Bell, 2013). The template requires teachers to reflect on each of these components to better inform the decisions made in the plan for differentiation.

Teachers should use data collected in the former component of the differentiation plan to identify supports for individuals and groups. In differentiating instruction, it is essential for teachers to also consider learning environment, curriculum, assessment, classroom leadership or management, and instruction. A classroom should be a safe learning space for all students, with a high quality curriculum, rooted in goals that can be measured with pre- and post-assessments. Additionally, students must understand the role of differentiation and receive quality instruction that is aligned to the goals of the lesson (Whitworth, Maeng, & Bell, 2013). The lesson planning template requires the teacher to reflect on these various factors in drafting a plan to support the needs of all students in class.

Introduction Lesson

One of the challenges in implementing inquiry-based instruction is the unfamiliarity of with the roles that students and teachers must play for effective inquiry. Students may become frustrated with the level of autonomy and teachers may struggle with serving as a facilitator,
rather than transmitting knowledge to students. The deviation from the traditional, didactic model of teaching may create tension in the learning process (Bunterm et al., 2014). The introductory lesson, then, serves as one method to mitigate the discomfort that students may use.

The introductory lesson (Appendix B) aligns most with confirmatory or structured inquiry, where the guiding question and procedure for uncovering and representing findings is determined by the teacher (Zion & Mendelovici, 2012). The lesson focuses on building student collaboration and creating opportunities for research, while defining key components of inquiry.

The introductory lesson features each phase of inquiry and uses multiple activities to achieve the goals of each phase. In the engage phase, students are asked to brainstorm about inquiry using the activity “Affinity Diagram” (Kruse, 2010). During the Explore phase, students will conduct research through a teacher designed WebQuest using computers on one of the following topics: teacher’s job in inquiry, student’s job in inquiry, confirmatory inquiry, structured inquiry, guided inquiry, or open inquiry. Students will collect their learning by describing what each topic looks like, sounds like, and feels like in a “Y-Chart” (Kruse, 2010). The Explain phase will require collaborative groups to present their findings and individual students to pull out major themes for each topic. Finally, students will reflect on the impact of inquiry on larger scales during the Extend phase.

**Scope and Sequence/Gradual Release Framework**

Change is a process that takes time and persistence. Change is most effective when it is clearly defined and students have opportunities to collaborate and navigate the various levels of comfort that may arise from the process (Olson & Loucks-Horsley, 2000). The need for a gradual change and process for students to build their expertise in inquiry-based learning requires a use of components of the gradual release of responsibility instructional framework.
(Fisher & Frey, 2013). The gradual release of responsibility framework may happen over any period of time and focuses on the shift from teacher-as-model to independent practice and application by students (Fisher & Frey, 2013).

This resource consists of two diagrams that can be used as guidance for implementing inquiry-based instruction throughout the school year. Figure 1 depicts the gradual release of teacher responsibility to student responsibility using the various structures of inquiry. Direct instruction occurs when a teacher provides students with a clear goal and models how an experienced mathematician would interact with a question or problem (Fisher & Frey, 2013). Confirmatory inquiry provides students with the most guidance from the teacher. The remaining modes of inquiry represent a range of approaches based on the level of autonomy granted to students, ranging from structured, teacher-directed procedures to student-directed open inquiry (Zion & Mendelovici, 2012). This transition and gradual release to open inquiry is the first tool in developing a timeline of implementation throughout the year.

The second component of this tool provides a model for supporting students in learning through the various modes of inquiry-based instruction (see Figure 2). The gradual release into inquiry depicted in Figure 2 features three main ideas. First, as explained previously, students should be gradually exposed to new forms of inquiry throughout the year. Also, students should have acquired the skills and knowledge and have access to the materials necessary to be successful in the new mode of inquiry before it is introduced. In addition, students should be exposed to a variety of inquiry structures throughout the year. Each of these ideas is essential to successful implementation of student ownership and inquiry in mathematics.
Figure 1. Transition from teacher responsibility to student responsibility at various levels of inquiry. Adapted from Better Learning Through Structured Teaching: A Framework for the Gradual Release of Responsibility, 2nd Edition (p. 3), by D. Fisher and N. Frey, 2013, Alexandria, VA: ASCD.

A key component of successful implementation of a gradual release model involving collaboration is the support provided to students in developing the skills required to work collaboratively. Thus, start of the timeline features a 20 day period in which teachers use direct instruction or confirmatory inquiry to build students’ capacities for working independently and collaboratively (Fisher & Frey, 2013). Teachers must determine specific tasks that will be necessary throughout the phases of inquiry (i.e. using computers, completing an independent reading assignment, acquiring materials, procedures and processes for the classroom) and develop a process for supporting students in acquiring the knowledge and skills of each task. This is especially important at the beginning of the year, but also must continue throughout the year in order to truly support students in the gradual release into all modes of inquiry (Fisher &
Frey, 2013). Thus, before introducing students to a new form of inquiry, teachers must ask the questions, “Have students acquired the skills and knowledge necessary for participating in the next level of inquiry” and “Do students have access to the materials needed to participate in the next level of inquiry.”

![Figure 2. School year model for implementing various levels of inquiry. Created by Jennifer Smith, 2015.](image)

Implementing an inquiry-based framework to mathematics instruction has many benefits, as explained in Chapter Two. Yet, inquiry should not serve as the single teaching approach for every lesson. Additionally, some lessons may utilize some components of inquiry, but not others. As students learn new methods of inquiry, teachers should identify which mode of inquiry best
serves the needs of students and aligns to the outcomes listed in mathematics standards (Olson & Loucks-Horsely, 2000).

**Classroom Layout and Seating Arrangements**

An essential component of inquiry is collaboration between students and their peers (OECD, 1999). In order to facilitate this type of learning, the physical space of a classroom must reflect this priority. The model in Figure 3 shows one structure for promoting collaboration in the classroom. This model promotes pods of four to five students working in each group, with a maximum of two types of resources or technology for each group (i.e. computers, calculators, rulers) to encourage collaboration (Bielenberg, 2013).

![Figure 3. Classroom layout for inquiry activities. Created by Jennifer Smith, 2015.](image-url)
This potential structure creates space for 30 students to work in pods. Additionally, students may work in smaller groups at each of the tables if the activity requires this. These pods can be achieved by using tables or combining independent desks to create larger groups. In placing the pods in a circle, space is created for the teacher to reach all groups quickly and with ease. This change also removes the teacher from the front of the room, creating a clear distinction between the inquiry environment and the traditional classroom. By breaking the plane of teacher and students, the teacher can more easily take on the role as facilitator (Marshall & Horton, 2011). This layout also identifies a space where activity materials can be kept and accessed by students for research or implementation of a procedure.

**Classroom Accessories for Inquiry Learning**

As students learn and engage with the various processes of inquiry-based learning, classroom accessories may be used to support students in their learning. These tools (Appendices C-F) feature supports and accessories that align to the skills and habits of each phase of inquiry.

An essential part of the Engage phase is to invest students in the content and build curiosity around the topic being covered (Marshall & Horton, 2011). As a result, students may develop additional questions unrelated to the topic being covered during the lesson. As the teacher’s goal is to inspire curiosity, an important support is a place to collect these questions. Teachers can use a jar or “parking lot” poster (Appendix C). Teachers can then set aside collaborative time to address questions generated by students or use them relevantly in future lessons (Ness, 2014). This tool contains an example of a parking lot that can be used to collect student questions.

In developing supports for the Explore phase, students will need access to resources and manipulatives that make exploring content more meaningful. Additionally, starting in the
Explore phase, and more generally for supporting students in their learning through the inquiry model, students should receive support in building the self-awareness associated with inquiry. One method to support this development of self-awareness is to use anchor charts that support students in internalizing important information without the assistance of the teacher. While students will need to be taught to use and refer to anchor charts, they can serve as staples and reminders for students who may forget their responsibilities throughout the inquiry process (Bailey & Pransky, 2014). This tool (Appendix D) contains a general framework for Y-Charts.

During the Explain phase, teachers aim to support students in the development of relevant academic language (Piyayodilokchai et al., 2013). A visual technique for supporting students in this development is a word wall (Appendix E). To enhance the development of students’ content knowledge, general academic language development, and writing and discussion skills, an effective word wall can be split into four categories: (1) content words, (2) general academic words, (3) classroom discussion terms, and (4) terms for writing. While there may be overlap, this format supports both teacher and student in the continual use of the word wall (Zwiers, 2014). This tool contains multiple examples of word walls.

The Extend phase creates space for students to consider the relationship between their learnings and the real-world (Piyayodilokchai et al., 2013). Displaying these connections can serve as a consistent reminder of the larger impact of learning content. This tool (Appendix F) contains an example display of real-world connections in a mathematics classroom.

**Assessment/Rubric**

Regardless of the focus of the content, teachers are accountable for ensuring that students develop the skills, information, and techniques that students need to be successful in class and life. As the assessment and reflection of student progress often is the responsibility of the
teacher, students frequently lose an opportunity to be reflective and develop self-direction. Thus, in the inquiry-framework, as the focus shifts to student-centeredness, the assessment of inquiry skills and mindsets must also become the student’s responsibility (Clark, 2014).

The inquiry skills and knowledge rubric (Appendix G) can be used by the students and the teacher to reflect on the development of the skills and mindsets explored in Chapter Two as benefits of the inquiry model. Students can then track growth in these skills and mindsets throughout the year. The rubric is broken down into groupings of skills and mindsets associated with each phase of inquiry. The students’ reflections on the rubric culminate in a final reflection in which students can identify focus areas and develop a plan for supporting growth in these areas. This plan helps build self-awareness for the students and also gives the teacher key insights about where the students are in their development and what supports the teacher can provide to push their growth (Clark, 2014).

This assessment is most effective if used in conjunction with other forms of assessment to paint a more holistic picture of the learner. As mentioned previously, teachers must also be held accountable for student mastery of content and must develop assessments that provide evidence of student understanding. Teachers are also accountable for the development of strong writing and presentation skills throughout the Explain phase. Additional resources for assessing development in writing a presentation are included in the Bibliography of Resources tool (Appendix I).

**Technology Guidance to Enhance Inquiry Learning**

Technology is shown to be an important component in successful implementation of inquiry-based instruction. It provides students with a broader access to information and creates more opportunities for students to feel as though their learning is associated with the real world
Technology integration must go beyond teaching students word processing skills, and instead focuses on student driven use of the Internet, digital cameras, software, and other programs to enhance their learning experience and utilize resources from a variety of sources and geographical locations (Coffman, 2012).

This tool (Appendix H) identifies specific activities and more general opportunities to integrate technology into all phases of the inquiry framework. The activities described are valuable to the learning process of students because they support the development of technological awareness. Additionally, teachers who use the activities described in the tool tend to emphasize higher levels of Bloom’s Taxonomy tasks, as many require students to analyze, synthesize, and evaluate the content being explored (Coffman, 2012). Examples of these activities being used in a mathematics classroom are included in the Bibliography of Resources (Appendix I).

Bibliography of Resources for Inquiry Learning

The development and implementation of a strong inquiry-based framework requires many considerations and thoughtful planning, as shown in Chapter Two and the description of each tool. The Bibliography of Resources (Appendix I) identifies additional resources to support in the areas of planning, assessment, technology integration, and additional literature for students and teachers. Each of these resources aims to support teachers in implementing components of the framework and/or support students in developing investment, skills, and knowledge.

Synopsis of Reflection Log

As part of the development of each tool, I collected my reflections in a reflection log. This reflection log presented me with an opportunity to think critically about each tool and track critical changes. In reviewing my log, the most noteworthy reflections resulted from the creation
of the assessment rubric and the gradual release framework. For each of these tools, my intentions and vision changed throughout the creation process.

My intentions changed most significantly in the process of creating the rubric for assessing inquiry skills and mindsets. In the construction of this rubric, I noticed a significant challenge in staying rooted in the skills and mindsets that students were developing as a result of the inquiry process. As many resources that I used to support the development were intended for the use of teachers to explore the depth of inquiry in the activities they developed, I had to ensure I was assessing skills and knowledge that were in the control of students, rather than teachers.

Initial variations of the rubric became too focused on outcomes that were in the control of the teacher, rather than the students. For example, the first draft contained an assessment of the students’ involvement in developing a question for the inquiry activity. While, ultimately, students should be involved in this process, the teacher, not the students, determines this involvement while planning the lesson. This realization pushed me back to the original reason for having a rubric and the need for students to have the opportunity to reflect on their growth. Thus, the final version is rooted in the benefits of inquiry-based instruction described in Chapter Two.

In the creation of the gradual release framework, I encountered similar changes in my thinking throughout the process as a result of my learnings through additional research. In my original planning, I had hoped to create a timeline that created clear transitions to more autonomous modes of inquiry at specific points in the school year. In searching for additional research, I struggled to find information that supported these clear transitions. Instead, I found more evidence that a variety of structures should be used throughout the year, with transitions to more autonomy occurring as a result of students’ readiness and preparedness. Thus, the final
version of the tool supports various approaches to instruction, informed by the ability for students to development appropriate skills and knowledge.

Summary

I intended to answer the research question: *How can inquiry-based instruction be implemented in a secondary mathematics classroom?* In doing so, I have generated a set of tools that support the planning and implementation for teachers and the development of the skills and mindsets of students. I have created a lesson plan template to support in planning each phase of the inquiry model, an introductory sample lesson to serve as an exemplar and a support for student learning, a scope and sequence outlining the processes of preparing students for open inquiry, a classroom layout diagram to support the development of a collaborative learning environment, a description of classroom accessories and supports that assist in student learning, assessment resources that hold students and teachers accountable for the development of students’ inquiry skills and mindsets, a guide for the use of technology in each phase to enhance student learning and real-world connectivity, and a bibliography of additional resources to support in implementing the framework. In Chapter Five, I will share a summary of my literature review, limitations of my work, possible implications of my work, and future research concerning my topic.
CHAPTER FIVE

Conclusions

Introduction

The question I am sought to answer is: *How can inquiry-based instruction be implemented in a secondary mathematics classroom?* I developed this question because of my experiences as a student, teacher, and instructional coach in a secondary mathematics classroom. Having learned math through in a way that required me to listen to my teacher and regurgitate the processes I’d witnessed, and initially developing my teacher identity around this model, I recognize that a transmission approach to teaching may not be the most beneficial for student learning and retention. In answering this question, I hope to better support the teachers I coach and prepare myself for reentering the classroom.

To answer my question, I developed tools and resources that support teachers in implementing an inquiry-based framework in a secondary mathematics classroom. I created a lesson planning template to support teachers in planning an effective lesson, a sample introductory lesson to support teachers in introducing students to inquiry, and a scope and sequence for the gradual release of inquiry to eliminate barriers that students may encounter as a result of exposure to a new, unfamiliar format of instruction. To support teachers in building an effective learning environment, I created classroom layout resources and classroom accessory resources. Additionally, to build accountability for developing the skills students need to be successful in class and in life, I created assessments for inquiry. Finally, I also created a technology guide and a bibliography of resources for teachers to support in implementing inquiry-based instruction.
In this chapter, I synthesize my findings and learnings throughout the process of developing a framework for implementing inquiry-based instruction in a secondary mathematics classroom. I will describe the limitations of my work, as well as possible implications. Finally, I will consider possible future research related to my question and topic of study.

Inquiry-based models require a student-centered environment in which teachers guide and support, and students are active members of the learning community. The structures of inquiry may vary in each lesson, but can generally be characterized by four phases: Engage, Explore, Explain, and Extend (Marshall & Horton, 2011). Additionally, structures of inquiry can be characterized by the level of autonomy granted to students, ranging from least autonomous in confirmatory inquiry, to most autonomous in open inquiry least autonomous structure, as students are asked to confirm knowledge that they already possess (Whitworth, Maeng, & Bell, 2013).

Research suggests there are many benefits of using an inquiry-based model in the classroom, and despite this, challenges may arise as a result of the transition from a traditional, didactic setting. Some of these benefits include positive impacts on student learning, retention, critical thinking, motivation, and higher level thinking (Harlen, 2013). An inquiry-based model must be implemented with the proper supports. Without these supports, teachers and students may struggle with unfamiliarity and insecurity when implementing this new structure (Bunterm et al., 2014).

Implementing inquiry-based instruction in a mathematics classroom is necessary as recent research continually supports the need for a more student-centered learning experience (U.S. Department of Education, 2008). Inquiry in mathematics requires students and teachers to
focus on higher-level thinking, moving away from procedural recall and a focus on math facts. An inquiry-based mathematics classroom must create space for students to work with their peers daily through group work and solving problems that require the application of various skills, rooted in application to the real-world (Cole and Wasburn-Moses, 2010).

The creation of this framework was rooted in mitigating the challenges that may arise as an inquiry-based structure is introduced in a secondary mathematics classroom. Zion et al. (2004) describe one of these challenges as teacher knowledge of how to plan for inquiry and how to support students through this learning process. For this reason, the lesson planning template, classroom layout, classroom accessories and supports, technology integration guide, and bibliography of resources were created to support teachers in the planning for lessons, creating a space that is conducive to learning and generating lessons that are engaging. These resources focus on eliminating the challenges related to teacher unpreparedness and unfamiliarity with the structures of inquiry.

An additional challenge that may arise is related to students’ unfamiliarity with inquiry-based instruction. Students may be unfamiliar with the skills and processes associated with inquiry, as many of them are used to the didactic, traditional model (Harlen, 2013). Students may be unsure of the new expectations in the inquiry-based model as they are asked to become more responsible for their own learning (Spronken-Smith et al., 2011). In my work as a teacher and in my current role developing teachers, I have seen students become intimidated and disinvested by inquiry when it is introduced at the beginning of the year with little transparency and support from the teacher. In my experiences, I have seen students become more receptive to inquiry when they understand the purpose and can anticipate the level of independence that will be required throughout the lesson. Thus, the introductory lesson, gradual release framework, and
assessment rubric were created to support students in becoming familiar with the skills and autonomy of inquiry, as well as to hold them accountable for the skills and mindsets that are linked to inquiry-based instruction.

Limitations

In creating this framework, limitations existed in ensuring that the tools are effective and appropriate for use in the mathematics classroom. The most impactful limitation was the fact that I am not currently teaching in a classroom and am, instead, coaching teachers on implementing components of the inquiry-based instructional framework. While I supported my teachers in implementing components of the framework, time constraints impacted my ability to understand the long-term implications and benefits of the tools I created and the inquiry-based framework in general. As I interact with most of my teachers once a month, I am limited by the amount of feedback I can receive about the implementation of an inquiry-based framework.

Many of the tools created are used to support teachers and students in developing awareness and comfort within the inquiry model. While the decision-making within the creation of each tool is rooted in research, without seeing students and teachers interact with the framework over an entire year, it is not possible to see whether or not students and teachers can truly benefit from these tools.

The timeline for the creation of these tools also served as a limitation. As the completion of these tools occurred during the spring, I was not able to create as many opportunities for the tools to be used during the school year. Many of the tools refer to the school year as a whole, or should be implemented at the start of the school year. Additionally, much of the professional development that my teachers receive occurs during the summer, rather than during the school
year. These timeline limitations, while creating some challenges, also create opportunities for future implications.

Implications

In my current and future roles there are many implications for this framework. As I support my mathematics teachers in their development and the growth and learning of their students, each of my tools can be shared as a whole or in parts with each of my teachers. By having multiple tools to choose from, I can select the tool that I believe will have the largest impact on each individual teacher and their students.

As my intention is to return to the classroom, my plan is to utilize each tool in creating a classroom culture and learning experience that is rooted in the inquiry-based model. With tools that outline supporting students from the start of the year on, a clear implication for my future students is the potential learnings and development of inquiry skills and mindsets. Additionally, I hope to share my findings and tools with interested teachers at my future school to impact a larger group of students and build consistency across my mathematics department.

I also intend to use this information to develop a workshop for future use in state and local conferences, as well as in any future opportunities to support the development of new teachers in my current position. In creating a workshop, I can share my findings and tools, impacting the planning and teaching in many classrooms and broadening my impact on student learning.

Recommendations for Future Research

Much of the research about inquiry-based instruction refers to its implementation in a science classroom. The development of my framework was rooted in the need for a more student-centered approach to mathematics education, coupled with the notion that inquiry-based
instruction provides this structure and additional benefits. This notion built on syllogism suggests additional research may be necessary to understand the true benefits of inquiry-based instruction in a mathematics classroom.

There are also clear gaps in research around the most effective way to implement inquiry and support students and teachers with the challenges that arise as a result of implementing inquiry. While research exists that identifies the challenges, little research exists that identifies strategies and tools to support effective implementation.

As a result of these gaps in research, challenges arose in narrowing the focus of the tools to their use in a mathematics classroom. While each tool is applicable to a math classroom, there appears to be potential for many of the tools to be used in various content areas. While this has potential to increase the implications of the tools, if this process were repeated, an important priority lies in attempting to narrow the focus in the creation of each tool to create clear connections to use in a secondary mathematics classroom.

Summary

This framework was created to assist secondary mathematics teachers in implementing an inquiry-based framework and to support students in developing a deeper investment and stronger understanding of mathematics content. As a student, I wish I would have had a chance to experience inquiry-based instruction. If my teachers had used inquiry, I may have developed deeper conceptual understanding of content and may have found my love of mathematics earlier in my life. With inquiry, I may have been more eager for challenges and problem solving opportunities, resulting in fewer pages lined with the number of minutes left in class. I would have left my classrooms feeling less like a computer, and more like a detective, confident and hungry to solve problems and overcome challenges.
Instead, as a student, I recognized that my experiences with math left me feeling like the content existed to be memorized and regurgitated. As a result, I didn’t prioritize long-term knowledge or skills and merely memorized facts and processes. This tendency seeped into the development of my own teacher identity, as I set up similar expectations in my own classroom.

Observing my students frustrations and struggles was the push I needed to recognize that a teacher-centered approach to learning mathematics would not set them up for success in my classroom or in life. In developing these tools, I hope to impact my future students in a way that deviates from my own experiences as a student and a first-year teacher. By entering the school year with a clear plan for supporting my students in developing the skills and mindsets of life-long learners, these tools will ensure that my students are confident, passionate, future leaders. This capstone has certainly helped me begin to answer the question: *How can inquiry-based instruction be implemented in a secondary mathematics classroom?*
Appendix A

Lesson Planning Template
<table>
<thead>
<tr>
<th>Subject:</th>
<th>Grade:</th>
<th>Unit:</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Big Idea(s):</th>
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</table>

<table>
<thead>
<tr>
<th>Essential Questions:</th>
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</table>

<table>
<thead>
<tr>
<th>Standard/Benchmark:</th>
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<table>
<thead>
<tr>
<th>Lesson Objective:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Inquiry Type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Circle one)</td>
</tr>
<tr>
<td>Confirmatory</td>
</tr>
<tr>
<td>Structured</td>
</tr>
<tr>
<td>Guided</td>
</tr>
<tr>
<td>Open</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content:</td>
</tr>
<tr>
<td><em>How will students display mastery of content through formative and summative assessment?</em></td>
</tr>
<tr>
<td><strong>Formative:</strong></td>
</tr>
<tr>
<td><strong>Summative:</strong></td>
</tr>
</tbody>
</table>

<p>| Inquiry Mindsets/Skills: |
| <em>How will students display growth in inquiry skills and mindsets (rubric)?</em>  |
| <strong>Formative:</strong> |
| <strong>Summative:</strong> |</p>
<table>
<thead>
<tr>
<th><strong>ENGAGE</strong></th>
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<tr>
<td><strong>Prior Knowledge:</strong></td>
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<td><strong>Activity:</strong></td>
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<table>
<thead>
<tr>
<th><strong>EXPLORE</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Questions:</strong></td>
</tr>
<tr>
<td><strong>Activity:</strong></td>
</tr>
<tr>
<td><strong>Materials/Technology:</strong></td>
</tr>
<tr>
<td>EXPLAIN</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Academic Language:</td>
</tr>
</tbody>
</table>

| EXTEND | Activity: | How will students apply their learnings to new scenarios? How will students connect their learning to the real world? |

| Differentiation | Student Readiness: | How will student skills and knowledge be assessed, and variance in student readiness by incorporated in the lesson? |
| | Learning Profile: | How will students’ identities (gender, culture, learning style, etc.) be utilized in this lesson? |
| | Student Interest: | How will this lesson appeal to student’s interests and spark curiosity? |
| Differentiation Plan: | Identify individuals or groups of students and specific supports for differentiation in the lesson? Consider the learning environment, curriculum, assessment, classroom leadership, and/or instruction. |

*Created by Jennifer Smith, 2015*
Appendix B

Sample Introductory Lesson
<table>
<thead>
<tr>
<th>Subject: Math – All</th>
<th>Grade: Secondary</th>
<th>Unit: 1</th>
<th>Date: 1-2 days During 1st 20 days</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Big Idea(s):</strong></td>
<td>Introduction to our class</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Essential Questions:</strong></td>
<td>How can we maximize our learning in math class?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Standard/Benchmark:</strong></td>
<td>CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lesson Objective:</strong></td>
<td>Students will be able to define the modes of inquiry.</td>
<td></td>
<td>Students will be able to apply inquiry to our math class and explain its impact on student learning.</td>
</tr>
<tr>
<td><strong>Inquiry Type:</strong></td>
<td>Confirmatory</td>
<td><strong>Structured</strong></td>
<td>Guided</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Content:</strong></td>
<td>How will students display mastery of content through formative and summative assessment?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teacher will use “fist-to-five” to check student comfort with content at end of engage phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Formative:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students will complete “Nine Card Possible Sentences” using the following terms (Kruse, 2010): inquiry, teacher, student, math, confirmatory, structured, guided, open, learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Summative:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students will self-assess on the inquiry rubric at the end of the lesson.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inquiry Mindsets/Skills:</strong></td>
<td>How will students display growth in inquiry skills and mindsets (rubric)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students will complete “Two Stars and a Wish” about their collaboration in the middle of engage phase (Kruse, 2010). This gives students time to adjust participation and behavior before the end of this phase.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Formative:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students will self-assess on the inquiry rubric at the end of the lesson.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENGAGE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prior Knowledge:</strong></td>
<td>What skills/knowledge do students need to access in order to be successful in this lesson?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Students will be more successful in this lesson if they have accessed any prior knowledge about inquiry. Students should create individualized connections with the term to begin with a more solid foundation and promote stronger retention.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity:</strong></td>
<td>How will students access prior skills/knowledge? How will students find motivation and investment through this activity?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Affinity Diagram</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Each student is given a pad of sticky notes and directed to write</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
down as many things as possible about the word “inquiry” for 2 minutes.

2) Students work in their small group of 4 or 5 by placing all sticky notes at the center of the table. These are now considered communal property.

3) Within their groups, students attempt to create groups of related ideas or make “runs” of ideas that may be connected. Students can stack words that mean identical or nearly identical.

4) Once students have made groupings, the teacher provides each group with a stack of sticky notes of a different color.

5) As a group, students write headlines for each of the groups/“runs” they created.

6) Students display their creation on poster paper or the whiteboard.

(Kruse, 2010)

**EXPLORE**

<table>
<thead>
<tr>
<th>Questions:</th>
<th>When necessary, what questions will guide students in their exploration? What questions/tasks can be offered to help students puzzle through the exploration?</th>
</tr>
</thead>
</table>
| **Guiding Questions:** | 1) What is inquiry-based learning?  
2) How can does and inquiry-based approach impact student learning? |
| **Questions to support students in deeper learning.** | 1) How is inquiry different from and/or similar to ways you have learned in different classrooms?  
2) What does it mean to learn in an inquiry-based setting?  
3) What are the different levels of inquiry? How are they different?  
4) What is the student’s job in the inquiry model?  
5) What is the teacher’s job in the inquiry model?  
6) How can inquiry impact student learning?  
6.1) What helps you learn best? Are any of those strategies/ideas present in the inquiry-based learning environment?  
7) What are the benefits of inquiry? What are the challenges? |
| **Activity:** | What activity will support students in exploring the guiding question? What directions will students receive as a support? How will students collaborate with peers during this activity? |
| | 1) Students will be participating in a modified jigsaw to become experts on specific components of inquiry-based instruction. |
2) Each group will be given two computers and asked to focus on one of the following topics.
   1) Teacher’s job in inquiry
   2) Student’s job in inquiry
   3) Confirmatory Inquiry
   4) Structured Inquiry
   5) Guided Inquiry
   6) Open Inquiry

3) Students will learn about the topic through a WebQuest designed by the teacher. Students will read articles and watch videos selected by the teacher on the topic of inquiry.

4) Students will be asked to record learnings of each topic in a Y-Chart by identifying what the topic looks like, sounds like, and feels like.

Adapted from *Thinking tools for the inquiry classroom*, by D. Kruse, 2010, Melbourne, AUS: Education Services Australia.

### Materials/Technology:

*What materials and technology will be necessary for students to effectively explore the content?*

Students should have access to computers (2 per group)
Chart paper
Markers

Potential supports for students:

- [https://www.youtube.com/watch?v=u84ZsS6niPc](https://www.youtube.com/watch?v=u84ZsS6niPc)
- [http://www.thirteen.org/edonline/concept2class/inquiry/](http://www.thirteen.org/edonline/concept2class/inquiry/)

### EXPLAIN

**Summarize Results:**

*How will students summarize their findings from the explore phase? How will students share their findings with others?*

Students should display learning on Y-chart. Each group will present findings to the class in a group presentation. Students will be asked to
<table>
<thead>
<tr>
<th><strong>Academic Language:</strong></th>
<th>What academic language will need to be introduced/reinforced to support students in explaining?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autonomy</strong></td>
<td></td>
</tr>
</tbody>
</table>

**EXTEND**

<table>
<thead>
<tr>
<th><strong>Activity:</strong></th>
<th>How will students apply their learnings to new scenarios? How will students connect their learning to the real world?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students should extend their findings to the impact on their own learning in our class, and potentially all classes. Students will provide a written, drawn, or other response any of the following prompts:</td>
</tr>
<tr>
<td></td>
<td>How will using inquiry-based instruction in our class impact your learning?</td>
</tr>
<tr>
<td></td>
<td>How will your work in the inquiry-based model impact your learning in other classes?</td>
</tr>
<tr>
<td></td>
<td>How will your work in the inquiry-based model impact your life outside of school?</td>
</tr>
</tbody>
</table>

**Differentiation**

<table>
<thead>
<tr>
<th><strong>Student Readiness:</strong></th>
<th>How will student skills and knowledge be assessed, and variance in student readiness by incorporated in the lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students will have the opportunity to reflect on their understanding of inquiry in the engage phase of the lesson. Students will work in heterogeneous ability groups to ensure diversity in experience benefits the generated definitions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Learning Profile:</strong></th>
<th>How will students’ identities (gender, culture, learning style, etc.) be utilized in this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>This section will vary depending on the group of students I am working with.</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Student Interest:</strong></th>
<th>How will this lesson appeal to student’s interests and spark curiosity?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>This section will vary depending on the group of students I am working with.</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Differentiation Plan:**

Identify individuals or groups of students and specific supports for differentiation in the lesson? Consider the learning environment, curriculum, assessment, classroom leadership, and/or instruction.

This section will vary depending on the group of students I am working with.
Appendix C

Classroom Accessories and Supports: Engage Phase
## Engage: Supporting students in building curiosity about content.

### Question Jar/Parking Lot

Students may develop questions throughout the inquiry process, but especially as they begin to find investment in the topic covered in the lesson. To support student curiosity, teachers can capture students unanswered, off topic questions in a question jar or on a parking lot poster.

### Parking Lot

*Every question you have is valuable. If you have a question that may take us off topic, place it on a post-it note and stick it to this poster. We will come back to it at a later time!*

*Created by Jennifer Smith, 2015.*
Appendix D

Classroom Accessories and Supports: Explore Phase
**Explore:** Supports for helping students understand content and the expectations of the various modes of inquiry.

**Organization/Access to resources**

Students will need access to a variety of resources and should have some autonomy in selecting various materials, depending on the mode of inquiry being used. To support students in accessing appropriate resources, labeled bins may be used to help students identify and select resources.

The images below show examples of organization techniques in math classrooms.

*Picture from secondary math classroom.*

**Anchor Charts**

Students are asked to create Y-Charts during the Introductory Sample Lesson tool (Appendix B) that outline the student’s role in inquiry, the teacher’s role in inquiry, and the expectations of each mode of inquiry. By using these Y-Charts as anchor charts, students may be supported in their development of self-awareness (Bailey & Pransky, 2014).

Adapted from *Thinking tools for the inquiry classroom*, by D. Kruse, 2010, Melbourne, AUS: Education Services Australia.

*Created by Jennifer Smith, 2015*
Appendix E

Classroom Accessories and Supports: Explain Phase
**Word Wall**
A word wall can be a helpful, visual tool to support students in academic language development. After students have learned a new term, the teacher or the students can create a card for the word wall.

![Picture from secondary math classroom.](image)

The Four-Column Academic Word Wall, shown in the table below, can be used to also support students in the development of writing and discussion words, in addition to content and academic words.

<table>
<thead>
<tr>
<th>Content Words</th>
<th>General Academic Words</th>
<th>Classroom Discussion Terms</th>
<th>Terms for Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parabola</td>
<td>Convert between…</td>
<td>I believe that…</td>
<td>In conclusion</td>
</tr>
<tr>
<td>Mean</td>
<td>Define the problem…</td>
<td>We don’t understand…</td>
<td>The next step is…</td>
</tr>
<tr>
<td>Exponent</td>
<td>Tell whether the…</td>
<td>why…</td>
<td>By using the…</td>
</tr>
<tr>
<td>Slope</td>
<td>Construct a diagram…</td>
<td>I agree/disagree with…</td>
<td>I found this…</td>
</tr>
</tbody>
</table>

![Picture from secondary math classroom.](image)

*Created by Jennifer Smith, 2015*
Appendix F

Classroom Accessories and Supports: Extend Phase
Extend: Supporting students in connecting content to the real world.

Real World Connections

Seeing examples of how content relates to the real-world is an essential component of the inquiry framework. Thus, students could benefit from seeing examples of math in the real-world. The example below highlights the use of math in making purchases, driving, exercise, gardening, baking, and other connections.

Picture from secondary math classroom.

Created by Jennifer Smith, 2015
Appendix G

Assessment/Rubric for Inquiry Skills and Mindsets
<table>
<thead>
<tr>
<th>ENGAGE</th>
<th>Feature</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accessing Prior Knowledge</td>
<td>I did not identify any previously learned skills or knowledge related to the content.</td>
<td>I identified some previously learned skills or knowledge related to the content.</td>
<td>I identified many previously learned skills or knowledge related to the content, and can somewhat explain the connection to the newly learned skills and knowledge.</td>
<td>I identified many previously learned skills or knowledge related to the content, and can clearly explain the connection to the newly learned skills and knowledge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identifying learning goals</td>
<td>I don’t know the desired learning goal.</td>
<td>I have a vague sense of the desired learning goal.</td>
<td>I understand the desired learning goal.</td>
<td>I understand the desired learning goal and used it to plan my approach in today’s lesson.</td>
<td>I clearly understand the desired learning goal, can explain it in my own word, and used it to plan my approach in today’s lesson.</td>
</tr>
<tr>
<td></td>
<td>Investment in Content</td>
<td>I am neither invested in nor excited by the content.</td>
<td>I am somewhat interested in and excited by the content.</td>
<td>I am interested in and excited by the content.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Accessing Prior Knowledge**

- **0**: I did not identify any previously learned skills or knowledge related to the content.
- **1**: I identified some previously learned skills or knowledge related to the content.
- **2**: I identified many previously learned skills or knowledge related to the content, and can somewhat explain the connection to the newly learned skills and knowledge.
- **3**: I identified many previously learned skills or knowledge related to the content, and can clearly explain the connection to the newly learned skills and knowledge.
- **4**: I identified many previously learned skills or knowledge related to the content, and can clearly explain the connection to the newly learned skills and knowledge.

**Identifying learning goals**

- **0**: I don’t know the desired learning goal.
- **1**: I have a vague sense of the desired learning goal.
- **2**: I understand the desired learning goal.
- **3**: I understand the desired learning goal and used it to plan my approach in today’s lesson.
- **4**: I clearly understand the desired learning goal, can explain it in my own word, and used it to plan my approach in today’s lesson.

**Investment in Content**

- **0**: I am neither invested in nor excited by the content.
- **1**: I am somewhat interested in and excited by the content.
- **2**: I am interested in and excited by the content.
- **3**: I am interested in and excited by the content.
- **4**: I am interested in and excited by the content.
<table>
<thead>
<tr>
<th>EXPLORE</th>
<th>Feature</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking</td>
<td>No question was generated.</td>
<td>Learner needed support to identify appropriate questions.</td>
<td>Learner identified simple questions that could be easily answered.</td>
<td>Learner identified clear, open-ended questions leading to inquiry.</td>
<td>Learner identified interesting, open-ended questions leading to an in-depth inquiry.</td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>No documentation recorded.</td>
<td>Documentation is recorded only with peer/teacher assistance and reminders.</td>
<td>Documentation is recorded.</td>
<td>Documentation is recorded legibly in learner's own words and is somewhat organized.</td>
<td>Documentation is legibly recorded in student's own words and is well organized and readily retrievable by student.</td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td>Works alone to answer questions related to the topic.</td>
<td>Listens to ideas of others and uses this as answer to questions OR shares individual ideas with group and uses this as answer to question.</td>
<td>Shares ideas with others AND listens to ideas of peers to develop a synthesized answer to a question.</td>
<td>Shares ideas with others AND listens to ideas of peers to develop a synthesized answer to a question to promote a deeper collective group understanding of the content. Some members of the group contribute more than learner.</td>
<td>Shares ideas with others AND listens to ideas of peers to develop a synthesized answer to a question to promote a deeper collective group understanding of the content. Each member of the group contributes significantly to the group.</td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Explanation</strong></td>
<td>I did not provide any explanation for my solutions.</td>
<td>I provided any explanation for my solutions, but did not use any evidence.</td>
<td>I provided any explanation for my solutions using some evidence.</td>
<td>I provided any explanation for my solutions using all the evidence I collected.</td>
<td>I provided any explanation for my solutions using all the evidence I collected and an analysis of what the evidence shows.</td>
<td></td>
</tr>
<tr>
<td><strong>Academic Language Development</strong></td>
<td>I did not learn any new vocabulary.</td>
<td>I learned new content, academic, discussion, or writing vocabulary word.</td>
<td>I learned new content, academic, discussion, or writing vocabulary word and can define it in my own words.</td>
<td>I learned new content, academic, discussion, or writing vocabulary word and can define it based on my exploration in my own words.</td>
<td>I learned new content, academic, discussion, or writing vocabulary word, can define it based on my exploration in my own words and used it in my explanation of content.</td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Competence</strong></td>
<td>I am not capable of learning math.</td>
<td>I hope to become capable of learning math.</td>
<td>I am somewhat capable of learning math.</td>
<td>I am capable of learning math</td>
<td>I am very capable of learning math.</td>
<td></td>
</tr>
<tr>
<td><strong>Orientation towards learning math</strong></td>
<td>Learning math is not important.</td>
<td>Learning math is somewhat important.</td>
<td>Learning math is important so that I get a good grade.</td>
<td>Learning math is important for my life and my future.</td>
<td>Learning math is important for my life and my future and I can explain why.</td>
<td></td>
</tr>
<tr>
<td><strong>Independence/ Overcoming Challenges</strong></td>
<td>When I was faced with a challenge, I stopped working.</td>
<td>When I was faced with a challenge, I asked the teacher what to do.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connections to Real World</strong></td>
<td>I don’t see how this connects to the real world.</td>
<td>I can explain how this connects to the real world with my teachers help.</td>
<td>I can somewhat explain how this connects to the real world.</td>
<td>I can clearly explain how this connects to the real world.</td>
<td>I can clearly explain how this connects to the real world and can identify situations where I can apply what I learned today in my own life.</td>
<td></td>
</tr>
</tbody>
</table>
Reflection Synthesis

Consider the following questions and reflect on your growth and development in the skills and knowledge above.

1) Identify one feature area where you have made a lot of growth and/or feel successful. Explain why you have made growth in this area.

2) Identify one or two feature areas where you would like to make more growth. Why do you want to prioritize these areas?

3) Develop a plan to support your growth. What will you do during the next lesson, outside of school, or at any other time to support your growth in this area? How can your teacher help to support you and hold you accountable?
Appendix H

Technology Integration Guide for Inquiry Learning
## Technology Integration in Inquiry-Based Learning

<table>
<thead>
<tr>
<th>Tool</th>
<th>Purpose</th>
<th>How</th>
<th>Phases of Inquiry</th>
</tr>
</thead>
</table>
| Web-Ex        | An inquiry activity where most or all of the information is drawn from the web. This activity is teacher designed, yet the teacher serves as facilitator when students complete the activity. Students navigate through the quest independently or collaboratively with peers (Lacina, 2007). | WebQuests are often an Internet webpage that contains directions and links for students to engage with. An effective WebQuest has the following components:  
1. The Introduction: The teacher names the goals for the project and builds on the student’s prior knowledge.  
2. The Task: Students use higher-level thinking to develop an opinion or synthesize information.  
3. The Resources: The teacher includes various links to websites (or other resources) that provide students with the background knowledge that is essential to completing the task.  
4. The Process: In this section, the teacher includes the procedure students should follow to complete the WebQuest and any additional final product.  
5. The Evaluation: Students and the teacher can evaluate their products and participation throughout the WebQuest (Lacina, 2007). | All or part of the inquiry framework.                                                                 |
| Web Inquiry Activity | Similar to a WebQuest, this activity requires students to use the web. This activity provides more autonomy, as the teacher does not develop a set of directions for students, nor does she  
• The teacher only provides students with an engaging introduction, called the “Hook.”  
• Teacher serves as facilitator by asking questions and directing students to the appropriate resources that help them answer questions independently or collaboratively with peers.  
• The activity begins with an open-ended question formulated by the teacher and students must research data on the internet to find a solution | All or parts of the guided or open inquiry structure. |
provide a list of resources for students to refer to (Coffman, 2012).

- Guided Inquiry: teacher provides resources or asks directed questions to guide students in research.
- Open Inquiry: Students take the lead role in research and discovery. The teacher ensures that students are on task, productive, and focused.

Planning for a Web Inquiry:
1. Develop an open-ended question aligned to desired objective.
2. Identify Internet resources that help students develop a complete way to answer the question. The best resources are raw data, primary sources, and library databases.
3. Identify methods and structures students can use to investigate the data to best answer the question (i.e. small-group work, using a spreadsheet to organize, compute, and display data, or interviewing community members to collect primary data are some examples).
4. Determine potential answers to the question using multiple sources and multiple methods for presenting this new information to others (see presentation suggestions below) (Coffman, 2012).

| Telecollaborative Activity | • A telecollaborative activity focuses on collaboration with other students or experts in different geographical locations using online communication tools (i.e. LISTSERVs, message boards, real-time chat, and Web-based conferencing). Students can interact with people across the world or in the next room. • The teacher develops an open-ended question and asks students |

| | Explore, Explain, Extend |
to work collaborative with other students and/or experts in the field on authentic problem solving through the Internet.

- Students collect or reflect on raw data and share their findings with their telecollaborative group. Students can be supported by peers or experts as they go through the phases of inquiry.
- The teacher can design an activity and/or seek out and have students participate in an activity created by another party.
- Teachers can utilize some of the following resources/experiences to build the activity:
  o Email Correspondence
  o Question-and-answer services (i.e. Ask an Expert at http://www.ask.com/)
  o Electronic appearances/workshops led by experts
  o Online mentoring
  o Partnership with classrooms across the world

Planning for a Telecollaborative Activity:
1. Determine a focus standard or objective
2. Find a partner class or an expert in the field of study
3. Develop a plan for the methods of collaboration of students and the telecollaborative partners.
4. Identify any necessary content resources
5. Identify specific dates for data collection, sharing, and presentation of findings
| General Computer/Internet Use | Data Gathering | • Internet searches  
• multimedia encyclopedias  
• online interviews  
• content-specific software packages (Owens, Hester & Teale, 2002). | Explore |
|-----------------------------|----------------|----------------------------------------------------------------|--------|
| General Computer/Internet Use | Data Management | • notetaking  
• graphs  
• charts (Owens, Hester & Teale, 2002). | Explore Explain |
| General Computer/Internet Use | Presentation | • creating a brochure or other printed material  
• constructing a website  
• creating/writing a blog  
• crafting a Powerpoint presentation  
• written synthesis/summary (Owens, Hester & Teale, 2002). | Explain |

*Created by Jennifer Smith, 2015*
Appendix I

Bibliography of Additional Resources for Inquiry Learning
Planning for an Inquiry Lesson in Mathematics


This resource outlines activities to support each component of inquiry and describes specific techniques to support learners throughout each lesson. This resource also contains a spreadsheet linking each activity with the appropriate phase(s) it can be used with effectively.


This resource provides a general overview of implementing inquiry with real examples from science classrooms. While this resource is science focused, Chapter 7 features frequently asked questions regarding the implementation of inquiry and can easily be applied to any classroom.

Assessment and Inquiry


This resource contains specific traits and rubrics for assessment to support students in the development of their writing skills. As students work to become stronger during the Explain phase of the inquiry framework, this resource can help students and teachers target specific skills to grow as writers.

*This article contains details around developing strong rubrics and supporting students in using them as a form of evaluation. As students will need support in authentically and accurately reflecting on their growth and development, this resource provides insight into the process of preparing students for that process.*

**Integrating Technology**


*This book identifies processes for planning the activities listed in the technology integration tool (Appendix H) and provides specific examples of each activity as it may be used in a classroom.*

**Sample WebQuests for Math**

- Math Career Exploration WebQuest:
  

- Various WebQuests:
  

**Telecollaborative Initiatives**

- iEARN: A non-profit global network that allows teachers and students to collaborate on real-world issues and concerns using the Internet (available at [http://www.iearn.org/](http://www.iearn.org/)).
• Global SchoolNet: Links classrooms around the world with activities and projects that make a difference on a global scale (available at http://www.globalschoolnet.org/index.cfm).

• TEAMS Education Resources: A Resource Page provided by the Los Angeles County Office of Education (available at http://teams.lacoe.edu/documentation/projects/projects.html).

• ePals: An e-mail service for teachers to identify possible telecollaborative activities with classrooms around the world (available at http://www.epals.com/).

• International Telementoring Program: Provides mentoring opportunities for classrooms around the world from leaders in business and industry (available at http://www.telementor.org/) (Coffman, 2012).

**Texts for Students and Teachers**


*This text contains puzzles and brain teasers aimed to build investment in mathematics.*

*This can be used by students to build excitement, or by teachers to support in planning investing and engaging inquiry activities.*


*This text contains short detective stories for high school aged students. Each problem must be solved using mathematical knowledge. This text can be used by teachers for inspiration and to build potential problems to solve in the inquiry process.*

This novel features highlights an adventurous trip taken by two cousins. This engaging text requires students to follow the story of the cousins and solve mathematical challenges throughout the adventure. This text could be an engaging addition to a teacher’s library to build investment in content and support students in the development of critical thinking skills.


This text contains one minute real-world scenarios that must be solved by math. This resource can be used to help build excitement and engagement in the content by presenting it in a unique way and requiring students connect material to their lives.

*Created by Jennifer Smith, 2015*
REFERENCES


