Summer 2022

Unlocking Math Minds: Using Inquiry-based Instruction to Increase Student Engagement and Learning in a Third Grade Classroom

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Unlocking Math Minds: Using Inquiry-based Instruction to Increase Student Engagement and Learning in a Third Grade Classroom

by

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

Hamline University

Saint Paul, Minnesota

August 2022

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"If we teach today's students as we taught yesterday's, we rob them of tomorrow."

\- *John Dewey, 1916*

ACKNOWLEDGEMENTS

A very special thank you to my wife, Jen, and my two children, Emmett and Greta. Teaching has always been a dream of mine. Because of them, I get to live my dream everyday. Their ongoing support and positivity encouraging me to keep going is what enabled this project to be completed.

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CHAPTER ONE

Introduction

Background

"If we teach today's students as we taught yesterday's, we rob them of tomorrow." (www.everdaypower.com/johndeweyquotes). I first discovered this quote when researching project-based learning strategies for my social studies class this year. I then came across this quote by long-time science educator Curt Gabrielson (www.wisefamousquotes.com/inquirylearningquotes), "If you tell somebody something, you've forever robbed them of the opportunity to discover it for themselves". I highlight these two quotes as I feel they fully encompass my research to answer the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?* In this paper, I review literature from philosophers and educators who made education what it is today. I share new studies from educators and the recent changes made in education, specifically how teachers facilitate learning *for* and *with* their students. The purpose of the research conducted is to educate today's teachers on the powerful nature of inquiry and how it impacts student learning.

Before I can answer the question posed above, I must first answer the following questions: *What is inquiry? What is inquiry-based learning?* As defined by the Galileo Educational Network, "Inquiry is the dynamic process of being open to wonder and puzzlements and coming to know and understand the world" (What is inquiry?, n.d.). Alberta Education states that "Inquiry-based learning is a process where students are involved in their learning, formulate questions, investigate widely and then build new understandings, meanings and knowledge" (Focus on Inquiry, Alberta 2004). When creating a culture of inquiry in a math classroom, I am not talking about students immediately forming questions and guiding the lesson to where they want to go. That type of inquiry is utilized in classes such as social studies. In math instruction, there are standards and concepts that the students are expected to learn. Where inquiry enters is how the students learn those concepts. Rather than traditional teaching, which would be to tell the students they will be learning how to add multi-digit numbers and then telling them the algorithm, inquiry-based learning will present a problem and then ask the students a simple question, *What do you wonder?* When I state 'simple', I don't intend the question to be low-level thinking or easy to answer. What is meant by 'simple' is that it only takes one question to help prompt the students' thinking. Simple. *What do you wonder* is a common inquiry question. What if you used something different? *What do you notice? What seems incorrect in this scenario? How do you see these images?* Students are then allowed the freedom to explore the problem from their perspective and their entry point to the mathematical concept. Kühne (1995) suggests that using inquiry-based learning with students of all abilities can help them become more creative, more positive and more independent. This creativity and independence helps students solve the problem presented as well as develop skills for real-world problem solving in their future years.

Personal Experience

As I think back to my experiences in my elementary education, the following discussion comes to mind.

> "Students, take out your textbooks, and turn to page 83. Today you will be learning how to solve for the area of a triangle. I will be handing out a worksheet with examples followed by problems that you need to solve in class. Your homework will be problems 1 - 7 on page 85. The area of a triangle is simple. The formula is ½ (b x h)".

Does this sound familiar to you? Growing up in a small, rural community in northwestern Minnesota, my education was traditional. When I say traditional, I mean many, if not all, teachers used the method of rote learning. The classrooms were teacher-centered. Oftentimes, it felt like I was one of the students sitting in the front row in a classroom much like the one represented in Ferris Bueller's Day Off (1987). I had excellent teachers, many of which I still admire today. One may argue that they didn't know any better. That was how they were taught. That was the norm for teachers at that time. If they tried anything different, they would have been accused of being a rebel, much like John Keating from the movie, Dead Poets Society (1989).

Unfortunately, the methods described above are still used by many educators today. I remember a time when I was back home with my sister and her daughter. My niece, who was a sophomore at the time, was struggling through her mathematics homework. I jumped in to help her. I first asked what instruction and support she was given from her teacher. She told me that she was just given a few YouTube videos to watch and then given the assignment. I was so frustrated. We started from square one of the concept. Ultimately, she went from not understanding the concept to being able to successfully complete the problems on her own. Why was she able to do this? Because I did not simply tell her what to do. The algorithms meant nothing to her because she didn't know what they were doing or how they worked. She had the algorithm, but she needed the space to ask the questions. She needed the space to discover on her own - with guidance. Too many times, educators follow the teacher-driven model as described by Fennema and Carpenter (1991). This model shown below (Figure 1-1) assigns a central role to students' and teachers' thinking (Fennema and Carpenter, 1991). In this model, all of the thinking and decision making is controlled by the teacher, not by the student. This is where students, like my niece, begin their struggle with engagement in mathematics. In this model, the teacher is the content expert and they are basing their instruction on their expertise and presenting the problems based on the concept. It is "I tell. You do".

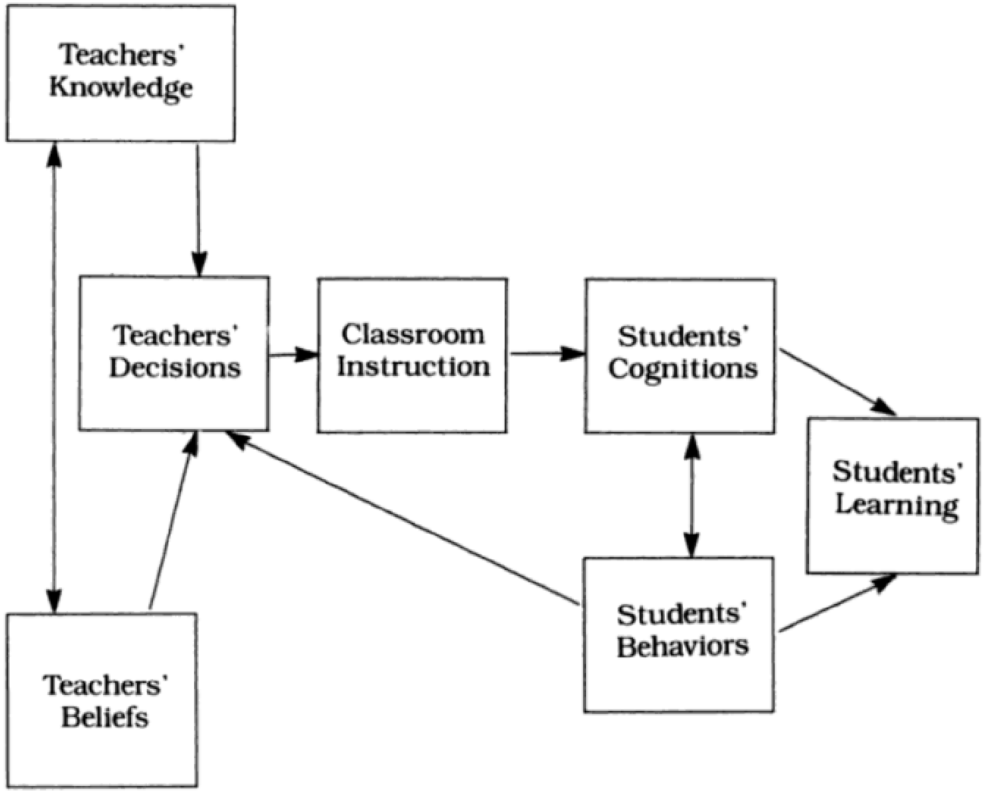

Figure 1-1. Model for research and curriculum development.

Flipping the model, and letting the student drive the learning allows them to meet the math problem where they are at and solve the problem in their way. This allows students to build confidence in their math abilities, which increases engagement and learning success.

Another method of teaching, which I feel can run parallel with inquiry-based instruction is cognitively guided instruction (CGI). Carpenter describes CGI as instructional decisions based on careful analyses of students' knowledge and the goals of instruction (1991). CGI is not discovery learning. It is purposeful and strategic. There are scaffolds put in place through the use of questions which help students understand the concepts, not because they are memorizing, but because they truly understand the concept and how it works. CGI is a pedagogy that works in conjunction with inquiry-based instruction because the student drives the thinking. In both pedagogies, the teacher is a facilitator, a coach, not simply an expert or a "holder of the knowledge", in a sense. Looking back at the story about my niece, following the traditional method would have enabled her to complete that assignment. At the same time, she most likely would have had the same perception of herself and math - that she is not a "math person" and math is not fun. By putting the learning in her hands, allowing her to explore and ask questions, she built confidence in herself. Her learning was long-term. She was inquiring, and she was learning.

After that moment, my dad looked at me and said, "You need to be a teacher. The world needs good ones." It was shortly after that moment that I enrolled at Hamline University to pursue my Elementary Education K-6 teaching license.

Professional Experience

I had always talked about changing the way I teach mathematics, but I never really knew how to do it. What I needed was the "ah ha" moment, and I had that moment a couple years ago. It was halfway through my first year teaching math to my sixth graders. I was saddened by how many of my students said, "I don't like math. I'm just not a math person." It was at that moment I knew that I needed to try something different. I had heard about Jo Boaler and her passion around helping all students engage in mathematics successfully. It was at that point, I decided to utilize her messages. I played two videos from her website (www.youcubed.org). One of the videos provided the students with four key messages.

1. There is no such thing as "smart people" and "not smart people". There is no such thing as a "math person".
2. When you believe in yourself, your brain works differently.
3. Mistakes grow your brain.
4. Speed is not important. It is important to think deeply and creatively.

I used those messages to create a math contract. I had every student sign the contract. I then had each student write down two things they can do to change their mindset. I chose ten of those statements and made them into the "Mathcenter Top 10". Both the contract and the "Mathcenter Top 10" were placed on a wall in the classroom. I wanted the students to know, first and foremost, that math is for everyone.

One of the most impactful messages was the importance for deep and creative thinking. Thinking deeply and creatively is the core of inquiry-based learning and instruction.

Later in the year, during my second professional observation, I was teaching a lesson on how to solve for the area of a triangle. Prior to this lesson, the students had solved for the area of a rectangle. To begin this lesson, I provided each student with a square. I started the lesson by asking the students, "How can you use what you know about the area of a square to solve for the area of a triangle?" A few of the students blurted out the formula. That was my fault, as I wasn't ready for that and I didn't give clear instructions. I then told the class that they could use the paper square to help. During this time, many of the students were able to turn the square into a triangle. At that point, we could talk about how the area of a triangle is half the area of a square. This was the start of inquiry-based learning. The students were engaged. The students were learning, because it wasn't simply "follow the leader" and do what I say.

After the lesson, during my post-observations meeting with my principal, I was given feedback on my lesson. My principal wondered why I spent so much time letting the students struggle through creating a triangle out of a square. She felt that much more practice and learning would take place if I would have "got to the formula quicker". It was at this moment that I challenged her. I told her that learning doesn't happen that way. Compliance does. I then explained to her how letting the students own their learning and letting the students discover how and why the formula works would increase their long-term learning. By simply telling the students and then sending them to their workbooks to practice, they are computing the problems and finding the correct solutions, but many times they are not understanding.

Utilizing this type of instruction, I saw students' engagement rise. I saw smiles. I heard students talking about math, saying that it was fun. One of my happiest moments was when I heard a student say, "Is it time to leave already? Math was fast today!" The student was engaged. The student was focused on learning and truly grasping the concepts, not just memorizing and completing a worksheet as quickly as possible. I was creating life-long learners.

Traditional versus Inquiry-Based Instruction

Since the beginning of math education and continuing into the education of today's students, many educators teach math by telling. For many years, students have received direct-instruction. Success in math was defined by being able to remember the correct algorithm and calculate the correct solution. Smith (1996), while making a case for reform in math instruction, describes the practice of math instructors. He paints the picture of a classroom in which the teacher is lecturing to the students. The students are being told (receiving) the facts, procedures, and algorithms for different problem types. There is one correct procedure for solving a problem. Educators provide direction and problems from the textbook, and the students' success is defined through their ability to memorize and apply the correct method for solving the problem posed to them. Their success is based on the expertise of the instructor, the transformation of information, and the students' innate ability.

The question that arises from this classroom description is this, "How does this traditional method of teaching create life-long mathematicians?" By definition, a mathematician is someone who is an expert or specialist of mathematics. One could challenge that by memorizing methods and procedures, being able to select the correct algorithm for a certain problem could create a great mathematician. This will work up to a certain point, but what happens when a student comes across a problem that they haven't seen before. They recognize the numbers; however, they are unsure of what to do with them. This scenario questions the effectiveness of traditional teaching. It is the foundation of Jo Boaler's research. In Boaler's book on mathematical mindset, she talks about how children today are introduced to formulas and algorithms before they are cognitively ready to be introduced to these procedures. Oftentimes, this leaves them confused. She continues to explain, saying that the inquisitiveness of children's early years fades away and is replaced by a strong belief that math is all about following instructions and rules (2015). Creating a classroom environment where students are shown an image or given a problem, but instead of being told what strategy to use to solve it, are instead told to come up with ways they think would work for the solution, is a classroom that supports inquiry-based instruction and learning. It is a classroom that doesn't simply teach the procedure and teach students how to compute. In order for our students to truly understand what they are learning, they need to ask questions, challenge each other and themselves. They need to wonder. They need to notice. They need to explore. This is the foundation of inquiry-based learning and instruction. This is how students become excited about mathematics. They begin to realize the importance of solving math problems, not just memorizing math solutions.

Summary

Entering my third year of teaching, I will have the opportunity to create life-long learners, which is the goal of every educator. I feel that the most effective way to create a life-long learner is to put the learning into the students' hands. They are the experts, I am the facilitator. It is true that in any content area as an educator, a certain level of content knowledge is required. It is why I challenge myself to learn something new continually. It is why I am conducting this research and creating a math curriculum for my third grade classroom. As I have described above, there are several reasons for the significance of inquiry-based learning and instruction. Specifically in math instruction, letting the student wonder and explore will allow for deeper thinking. This level of thinking will allow the student to go beyond memorization of a procedure. With inquiry-based instruction, students will be able to ask the questions they need to ask to understand the concept. They will be able to notice things. Students will be able to explore different solutions. Furthermore, they will be able to talk about those solutions and learn from each other. It is through this type of instruction that students become engaged mathematicians, critical thinkers, and problem solvers; not just human computers.

In Chapter 2, my research focuses on the benefits of inquiry-based learning and how educators can ensure that their students have the opportunity to engage in this type of learning. I provide several examples of how a student's cognitive development increases as a result of inquiry-based instructions. I provide research on the benefits of inquiry-based instruction versus the traditional rote/memorization pedagogy. There are researchers and educators that feel this isn't the best method for a students' learning. I provide insight to this challenge as well. After reading this chapter, I will have clearly documented information answering the question: *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?*

CHAPTER 2

Literature review

Introduction

As educators, it is our purpose and our responsibility to help facilitate our students' learning experiences to help them grow into life-long learners. The research presented in this chapter focuses on the *facilitation* of student learning. The research reviewed supports the answer to the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?*

First, I provide insight into the importance of inquiry-based learning. Within this section, I define inquiry-based learning and inquiry-based instruction. I explain how the theory of constructivism influenced inquiry-based learning. I also dive into the differences between a student-centered classroom and a teacher-centered classroom. Secondly, I examine the effects of inquiry-based instruction on student engagement and learning success. My review includes research that compares an inquiry-based classroom to a traditional classroom focusing on the difference in cognitive development and engagement. I present research on the long-term learning and understanding of mathematical concepts. I also conduct research on the improved problem-solving skills when encountering real-world problems. Lastly, I dive into how to implement inquiry-based instruction into the classroom. Inquiry-based instruction is not simply asking a question and then letting the students go to work. That is part of it, but what is done with the question and the conversation afterwards is what leads to a clearer understanding of the concept. I describe methods and strategies that educators have used or can use when implementing inquiry-based instruction. The themes presented in this review support my research question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?*

The Importance of Inquiry-Based Learning

What is Inquiry-Based Learning? The conducted research showed that there were many definitions for inquiry-based learning. Dewey (1910) believed that the learning process begins when the learner is placed in an environment that causes confusion or doubt. To progress beyond confusion and doubt, the learner engages in inquiry and reflective thinking. Alberta Focus on Inquiry (2004) defines inquiry as the dynamic process of being open to wonder and puzzlement and coming to know and understand the world. Inquiry-based learning is a process where the students are involved in their learning. The students create the questions and investigate them. From the investigations, they develop and build new understandings, meanings, and knowledge. A D Handayani et al (2018) describe inquiry-based learning as a model that encourages students to organize their own activities while studying mathematical statements. In this environment, students take responsibility for their own learning. The teacher guides the students by giving different mathematical activities. In all of the descriptions of inquiry and inquiry-based learning, there was one common theme. çIn the following sections, research is conducted on the differences and benefits between the student-centered model and the teacher-centered model. The inquiry-based classroom environment incorporates the student-centered model. In discussions with colleagues and in the literature reviewed, these two models are talked about frequently in general terms.

But what do the models truly describe? Clements and Batista (1990) define student-centered instruction as giving “preeminent value to the development of students’ personal mathematical ideas” (p. 35). With this model, the students are provided with opportunities to be an active participant in their knowledge gain of mathematics. This differs from the traditional teacher-centered model or teacher-directed model. Clements and Batista (1990) state that the goal of teacher-directed instruction is “transmitting sets of established facts, skills, and concepts to students” (p. 34). Bok (2006), when writing about a student-centered classroom, suggests that when students are working on their own, mentally challenging themselves, their learning is much more effective. Students are not able to recall what they learned when being lectured. Morgan et al (2015) states that student-centered strategies focus more on the understanding of the mathematical concept rather than procedural fluency. The research supports a student-centered environment where students are given a voice. Learning is active, not passive.

There are different types of inquiry-based learning. Mackenzie (2018) describes the different types as structured, controlled, guided, and free. The research presented in this paper is focused on guided inquiry. As discussed previously, with math instruction, because there are standards and concepts that students are expected to learn, the benefit of guided inquiry allows for students to take agency in their learning, while the educator guides students through their attainment of the mathematical concept. Mackenzie (2018) explains that guided inquiry as one where the teacher chooses the topics and questions, and the students then explore and determine the solution. When describing guided inquiry, Gialamas et al (2001) focus on the benefits for the student beyond the immediate acquisition of the concept or procedure. Guided inquiry encourages students to be active learners in their education. When doing so, they are able to go beyond the mathematics world and into their everyday world, making the math and learning more meaningful.

Another term used to describe inquiry-based learning is discovery. It is important to differentiate the two terms: discovery and guided inquiry, as they are different. Alfieri et al (2011) explains that discovery learning is a teaching method where students are not given the algorithm or conceptual procedure. Instead, the students are left alone to explore and discover how to solve the problem. Discovery learning is different, as the learning is completely on the student. There is very little, if any, guidance. Mayer (2004) cautions educators about the use of discovery learning without any assistance. It is good to give students the autonomy to solve a problem, but helping the students by scaffolding their learning is critical to the cognitive growth and acquisition of the mathematical concept. This is where the support through guided inquiry and the strategy of cognitively guided instruction is used.

When defining inquiry-based learning, it is critical to also describe what it is not. Duffy & Raymer (2010) provide four misconceptions about inquiry-based learning. With each misconception, they provide arguments supporting the benefits of inquiry-based learning. The first misconception is that students are given a problem and then the teacher lets them "sink or swim". It is true that inquiry-based learning provides an opportunity for students to explore what they know and what they don't know; however, as I explained above, there are different levels or types of inquiry. With guided inquiry, the teacher provides some level of guidance when needed. To provide that guidance, educators can use pedagogical strategies such as Cognitively Guided Instruction (CGI). Educators and psychologists understand that one of the ways students learn is through the construction of knowledge and experiences, which is the basis of constructivism. When using Cognitively Guided Instruction, educators construct and scaffold instructional moves based on the students' knowledge. The guidance is focused on encouraging the students' critical thinking skills and process in lieu of simply telling them what to do or what to listen to. It is not the simple transmission of procedural actions (Carpenter et al, 1996). Alfieri et al (2011) emphasized that students do not benefit or learn well when solely utilizing unassisted discovery learning. Students cannot simply be told to inquire and then be able to successfully do it, which is why there are different levels, types, or a "continuum" of inquiry (Banchi & Bell, 2008).

A second misconception is that whatever solution the student finds is correct because it was based on the student's findings and analysis. A key component of inquiry-based learning is allowing students to share their strategies for problem solving. That being said, it is also important to challenge the student's thinking as a part of this process.

The third misconception described is that there is no direct instruction. Inquiry-based learning includes direct instruction, but where the direct instruction *enters* the lesson is different. Before the teacher provides instruction, the students have been given time to struggle with the problem or questions posed by the teacher (Duffy & Raymer, 2010). Lastly, some researchers argue that inquiry-based learning is acceptable for higher-order thinking, but it is not effective for teaching technical or procedural skills. Duffy & Raymer (2010) acknowledge that when higher-order cognitive skills are being developed, there may be a need for classroom teachers to directly assist the students with these procedural skills. Oftentimes, these skills have been taught prior to this point, so many of the students are able to recall prior knowledge and use that knowledge to progress in the learning of the more challenging concept.

The research presented in this section paints the picture of what inquiry-based learning is. In the next section, inquiry-based instruction will be defined as well as the basis for inquiry, which is the theory of constructivism.

What is inquiry-based instruction? Similar to inquiry based learning, there are many descriptions as to what inquiry based instruction looks, sounds, and feels like. Ku et. al (2014) states that inquiry based instruction "emphasizes open-investigations of authentic problem scenarios in a student-centered and collaborative learning classroom context (p. 253). Kirschner et al (2006) describe inquiry-based instruction as a pedagogy with minimal guidance. "Minimal instruction", created by Carrol (1990), follows the guidelines of inquiry-based instruction. Students are not given specific or direct outcomes; however, there is a goal given for the content knowledge being taught. Throughout the instruction, students lead the class and where their learning goes. The teacher is a coach, providing assistance or guidance to help scaffold the students' learning. Success is defined by the transfer of knowledge and the changes in the students' efforts and outcomes throughout the learning process.

One of the key differences between inquiry-based instruction and the traditional, teacher-centered instruction is the outcome of the learner. With inquiry- based instruction, the focus is on "doing mathematics" (Bahr and DeGarcia, 2008). This is different from teacher-centered instruction, where the focus is on "knowing mathematics" (Baki, 1997). Baki continues by stating that the difference between knowing and doing is procedural versus conceptual. With inquiry-based instruction, described as activity-based instruction by Aremu & Salami (2013), students are able to think and learn beyond the procedure to solve a problem correctly. They are able to develop the concept, which can then be applied to real-world scenarios outside of the classroom. Markusic (2009) compares and contrasts the two different teaching methods by looking at knowledge direction and assessment. Using the student-centered or inquiry-based approach, students do not learn through transmission. Instead, they collect information and synthesize the information they find through critical thinking skills. The learning process is considered to be higher-order learning. With assessment, success is not determined through right or wrong. Success is determined by the inquiry process and development of concepts by the student. Success focuses on the explanation and conversation that comes from the exploration.

In the next section, the theory of constructivism is described. The following research describes how constructivism has influenced both the student and teacher practices in an inquiry-based learning environment.

How the Theory of Constructivism Influences Inquiry-Based Learning. As defined above, two main components of inquiry-based learning are exploration and building of knowledge through experiences. These components describe the constructivist theory. Simon (1995) states that constructivism specific to someone's learning is based on the person's experience and their prior knowledge. "New" knowledge is constructed from perspectives, perceptions, and experiences. Clements & Battista (2009) describe the basic components of constructivism as it relates to mathematical learning. There are five. The first component is that knowledge is active, not passive. This statement is the basis of Piaget's research on a child's psychological development. Piaget (as cited in McLeod, 2018) believed that children do not develop cognitively by taking in information. Development is not passive, but instead it is active. The second component is that children create new mathematical knowledge from their past or current experiences and actions. McLeod (2019) emphasizes this by stating that constructivism is the gaining of knowledge through experience and the act of doing. A third component is that there is not a pre-existing “right or wrong”. Mathematics is based on the discovery and interpretations of the individual. The fourth component is the importance of social interaction and discussion in the classroom. This relates closely to Vygotsky’s theory that learning and cognitive development is socially-constructed. His theory explained that learning takes place within the child’s environment and social interactions. Children develop from social interactions and the scaffolding performed by adults around them, all within the zone of proximal development (Vygotsky, 1978). The last component is that the teacher must not dictate the use of a specific method to solve a problem. This correlates with the third component described above. If students are told what the procedure is or method to be used, mathematics quickly becomes about memorization and compliance, not understanding.

The National Council of Teachers and Mathematics (2000) emphasizes the theory of constructivism in the revised standards. The focus on constructivism and inquiry has been at the front of mathematics reform discussions. The foundation for the constructivist approach is described in the standards as follows. First, knowledge is socially constructed. As referenced above, this is a core belief of Vygotsky and his theory of social construct (1978). Secondly, learning is a process that builds on personal knowledge and social interactions. These reflect both Piaget and Vygotsky’s research and theories. Lastly, teaching is facilitating students' learning by creating an inquiry-based environment. Cobb et al (1993) describe reform teaching in mathematics as a pedagogy that leaves the traditional teacher-centered classroom behind. Classrooms are now environments where concepts are developed through student discourse. Duffy (2009, as cited in Alfieri et al, 2011), explains that constructivist instruction allows for students to learn through inquiry. Students receive guidance from their teacher; however, the guidance comes as needed. Children learn from building on previous experiences and knowledge, not simply through transmission of knowledge from teacher to student.

Where constructivism and inquiry- based learning meet is in the manner of constructing knowledge. The constructing of knowledge is internal to the student. The student builds on their knowledge through inquiry and social interactions. Serafin et al (2015) describe inquiry-based learning as the development of knowledge through real-world problem solving and the posing of strategic questions. The following section provides examples of constructivist practices in classrooms and the benefits that students experience as a result of these practices.

Why is Inquiry-Based Learning important? The importance of inquiry-based learning is widely documented. As referenced in the previous section, one of the goals of the National Council for Teaching Mathematics (2000) is for students to be able to talk about mathematics. Earlier than 2000, The National Council for Teaching Mathematics (1989) states the following goals of mathematics in schools today, which support the importance of the change in mathematical instruction and learning:

> The fundamental goals of school mathematics are to teach students to understand and reason with mathematical concepts, solve problems arising

> from new and diverse contexts, and develop a sense of their own mathematical power These dramatic changes in the conceptions of mathematical content and activity are paralleled by equally radical changes in models of teaching and learning. Students are no longer seen as the recipients of knowledge transmitted directly from the teacher. They possess prior knowledge and intuitions that shape what they see, hear, and understand. In order to make sense of mathematics in their own terms, they must take mathematical actions: represent their ideas, make conjectures, build models, collaborate with other students, and give explanations and arguments.

The importance of this type of learning is supported through research in constructivism. Boaler et al (2021) describes the necessity for allowing students to explore, especially in their younger years. Her experience is that too often students are being taught to copy and use methods that the teacher uses and teaches. Students are not allowed to use their own methods. They aren't allowed to be curious and ask questions. For these reasons, students lack engagement in math because they are not allowed to think independently. They are not allowed to use their experiences or prior knowledge. Carpenter and Lehrer (1999) state that talking is not just important, but it is a benchmark of understanding. Inquiry is critical to a students' development and engagement in mathematics.

Inquiry-based learning provides students the opportunity to learn in a cooperative classroom setting. Cooperative learning is imperative in an inquiry-based classroom. The National Council for Teaching Mathematics (1989) focused on the importance of cooperative activities for students' growth and development as mathematicians. Hekimoglu and Sloan (2005) further describe this importance stating that cooperative learning helps students fully understand what they are learning, developing "mathematical judgment", and promoting the explanation and communication of mathematical concepts. Dowling and Ernest (1998) reference the implementation of cooperative learning strategies as an important form of social interaction. Both of these statements reflect the goals and objectives of the standards set forth by the National Council for Teaching Mathematics (2000). The American Mathematical Association of Two-Year Colleges (AMATYC) created standards that require the use of student-centered, interactive learning strategies when teaching mathematics (Panitz, 2000). The standards state that improvements in how students are taught is necessary for the students to become more active and involved in their learning. It further states the importance of cooperative learning, which not only helps them become better math students, but applies to the real-world once out of school.

Inquiry-based learning is a focus for the National Council for Teaching Mathematics. Its foundation is the theory of constructivism. In the following section, research is conducted on the effects of this type of teaching.

Effects of Inquiry-Based Instruction on Student Engagement and Learning Success

Hejny (2012) describes three goals of children's cognitive development in mathematics. The first is that the student understands mathematics. They are not just a "human computer" pumping out answers. Children's learning is more effective when they are able to fully-understand what they are being taught. Inquiry-based learning enhances critical thinking skills, makes learning more interesting, encourages curiosity, empowers students, and enhances comprehension (www.wabisabilearning.com, 14 June 2021). The second goal is that students are motivated to do math on their own because they are engaged, not frustrated. When students learn passively, they become disengaged and often stop learning mathematics as soon as they can (Boaler & Greeno, 2000). The third goal is that students develop globally in math. Specifically, students are able to explain their solutions to problems, they are working collaboratively with others in class, and they use what they know to solve something they don't. Lastly, they are given time to investigate their errors, so that they can learn and overcome misconceptions as well as correct their errors. The research provided in this section examines inquiry-based instruction and the effects on academic performance, focusing on increased engagement, more meaningful understanding of concepts, and development of problem-solving skills as well as insight into the social-emotional improvements, specifically with cooperative, collaborative learning and increased confidence.

In a study referenced in Education Week, researchers observed two different types of instruction: Teacher-directed (regular, traditional) and inquiry-based instruction. The researchers compared the range of scores on standardized math tests for each type of instruction. They found that when inquiry-based instruction was used at least four days a week, students improved significantly than students being taught traditionally. The average student in inquiry classes performed 0.18 of a standard deviation higher in math by the end of the school year (Sparks, 2019). This statistic is important, as it provides evidence to what an inquiry-based classroom environment can do for a student's achievement. Through inquiry-based instruction, student achievement is improved based on their engagement and long-term retention as a result of understanding the mathematical concepts rather than just memorizing them. In a study between a traditional mathematics classroom and a non-traditional classroom, Hiebert and Wearne (1993) found that the students in the non-traditional classroom had higher gains of academic success. In this classroom, the educator was asking the higher-order, "authentic" (Hiebert & Wearne, 1993) questions. Newman et al (1996) conducted a study with elementary, middle school, and high school students. The study focused on the content areas of mathematics and social studies. The results showed that not only did the academic achievement improve, but the gap between the high and low performing students greatly decreased with authentic, or inquiry-based instruction.

What multiple studies show, and specifically that results described in the paragraph above is that children learn better when they are "driving" their learning. They learn better when they are constructing knowledge rather than receiving knowledge. The "generation effect" (Slamecka & Graf, 1978, as cited in Alfieri et al, 2011) describes that memory is improved when students own their learning. Ownership of learning is further explained by letting the students discover and explore. It is not to say that students don't learn in a teacher-centered classroom model, it is that they learn differently. Friesen and Jardine (2009, as cited in Scott et al, 2018) describe the origin of the "factory model" education system. In this model the students' purpose was to follow rules and simply be able to memorize and repeat what they learned. The risk with rote memorization being the only way to learn is that students don't know how to apply what they have memorized to more difficult and challenging problems (Scott & Friesen, 2013).

So where then, does the best learning take place? This brings us back to the theory of constructivism and cooperative learning. As explained earlier in the literature review, constructivism is the gaining of knowledge through experience and the act of doing (McLeod, 2019). In a third-grade classroom study, McNeal (1995) follows a student that was taught math in two environments. The first environment was one grounded in inquiry, curiosity, discourse, and exploration. In this environment the children in the study were allowed to work individually or in pairs. They participated in class discussions to make conjectures. Problem-solving was validated through classroom challenges and discourse. In this classroom, the student that was observed and interviewed was able to speak to what they were doing. They could explain the mathematics. This same student was then placed in the second environment, which was a classroom that was teacher-centered. Students were given the algorithms as well as hints to solve problems. During this instruction, the same student that was able to explain mathematics was now unable to follow steps in the same type of mathematical problems. The student had lost reasoning and was following steps that they couldn't rationalize. During this instruction, the students would perform a task and look at the teacher for cues on whether or not their solutions were correct. Mistakes did not happen, because the students did not take risks. They did not explore. Without inquiry, students did not explain their solutions nor were they asked to explain them. The results of McNeal's study validated what we hear too often from young students. Mathematics is just a set of rules to follow. These problems have no connection to the student's lives outside of the classroom, which is why educator's often hear, "Why do we have to learn this?" This question can be avoided in an inquiry-based classroom. What this study shows is that a student's engagement and perception of mathematics changes based on the nature of the classroom. Furthermore, the research demonstrated that children develop cognitively through social interaction and discussion with peers. Cobb et al (2011) validate this when writing about a constructive approach. They state that in this environment, students know themselves better than the teacher. Because of this, the students are allowed the space and freedom to construct solutions and build upon them based on what they know or don't know. In their study, students were placed in different learning environments: teacher-centered and student-centered. In the teacher-centered classroom, students realized that mathematics was a problem-solving activity in which the students worked collaboratively to solve through discourse. Because of this, students did not exhibit feelings of anxiety or embarrassment. On the other hand, where students were given problems and expected to solve on their own and justify their answers, the feelings of frustration, anger, and disappointment were prevalent. In research conducted by Panitz (2000), when students use cooperative learning strategies, often incorporated in inquiry-based learning environments, students benefit. Their critical thinking skills improve. Their motivation levels improve. They have more fun in math. Together, their achievement increases. Beyond the classroom, students build relationships which enable discussions to happen once instruction has completed.

A 2007 survey in England displayed declining attitudes towards mathematics in students between the ages of nine and thirteen (Noyes, 2012). The decline in attitude was tied to students who were taught in a teacher-centered classroom. The conclusion of the study was that finding strategies for teachers to develop a student-centered pedagogy is critical.

In a study conducted in 2004, researchers found that through questioning, students were able to progress from primitive knowing, which is defined at what a person can do initially. This is the starting place for mathematical understanding (Warner & Schorr, 2004). The progression, in the end, takes them to formalizing, which is the phase where a person is able to use prior knowledge to construct new knowledge to form their understanding. This theory is called the Pirie/Kieren model, developed in 1994.

Calder (2013) writes that learning is enhanced when students have ownership in what they are learning. When this happens, students are able to apply their knowledge to real-world problems. Furthermore, he states that when students are given questions and asked to explore via inquiry, students' perspectives broaden and new understandings are developed.

What these studies and surveys show is that how students are taught affects their engagement and learning in mathematics. The National Research Council (2001) talks specifically about the benefits of a student-centered, inquiry-based classroom. Learning concepts and being able to understand and explain problem-solving helps students realize the usefulness of mathematical skills. This realization allows the learning of additional skills which leads to higher mathematical achievement. Furthermore, Parmar & Cawley (1991) state that opportunities for mathematical discussion and understanding strengthens students' metacognitive reasoning. Karina (2018) argues that not only should correct solutions be attained, but the theory developed to get the solutions is equally important.

There are five activities that A D Handayani et al (2018) describes about what children can perform as a result of inquiry-based learning. They are as follows:

1) Building deep knowledge and understanding, not just passively in receiving knowledge
2) Engaging directly in the process of discovering new knowledge

3) Finding conflicting ideas that transform knowledge and prior experience becomes a deep understanding
4) Transferring new knowledge and skills with new circumstances
5) Responsible for continuous learning and mastery of curriculum content and skills (par 6)

Inquiry-based instruction places students in an environment where they are given ownership of their learning. This ownership, along with cooperative learning strategies, gives students confidence to explore, confidence to try new strategies or their own strategies, and confidence to explain their position and where they are at in their learning of the mathematical concepts. Inquiry-based instruction allows students the time to understand what they are learning, not simply memorize what they are learning. In the next section, strategies and guidelines are provided to implement inquiry-based instruction in the classroom.

Pedagogic Approach with Inquiry-Based Instruction

Day (1982) describes the recipe for learning. The educator must first place the student in a situation of uncertainty. The student is then given autonomy. As that student's educator, it is important to get out of the way, and let the student explore. Research demonstrates that the student will enjoy their learning much more than a direct instructional environment.

Inquiry-based learning is not accomplished by accident. The educator's facilitation of the classroom is purposeful. It is imperative that the teacher sets the stage for the class. They must pose a question or problem and allow students to be able to explore, construct, and reflect on the problem-solving process. The teacher must be ready, have guiding questions, and design the learning experience, so that students can engage and learn to become explorers in mathematics (Richards, 1991). Cobb, Wood, and Yackel (1993) state that the teacher has more than one responsibility. It is the teacher's responsibility to foster the development of conceptual knowledge as well as facilitate the discussion of shared knowledge within the classroom. It is the teacher's role to provide an environment where students have the space to explore and use their prior knowledge. Teachers must also ensure that they are facilitating the discussion and cooperative learning between the students in the class. This falls in line with Vygotsky's (1978) theory of socialized learning.

Simon (1995) details the *Professional Standards for School Mathematics* (National Council of Teachers of Mathematics, 1991) which teachers' responsibilities in four key areas:

- Setting goals and selecting or creating mathematical *tasks* to help students achieve these goals;
- Stimulating and managing classroom *discourse* so that both the students and the teacher are clearer about what is being learned;
- Creating a classroom *environment* to support teaching and learning mathematics;
- *Analyzing* student learning, the mathematical tasks, and the environment in order to make ongoing instructional decisions (p. 5)

In his research, Simon translates Broussau's journal on the different roles of a teacher. Broussau emphasizes that students need to have freedom to respond to a situation on the basis of their past knowledge of the context and their developing mathematical understandings (Simon, 1995, p. 119). In addition to these four areas, the National Council for Teacher of Mathematics provides standards specific to discourse, which focuses on inquiry. This, along with the research provided in previous sections, reiterates the critical nature of inquiry in mathematics instruction. Mathematics is not just memorizing or knowing the specific content or procedure. It is defined by problem-solving, deep thinking, developing conjectures, and looking for and recognizing misconceptions (Jaworski, 1996) .

Much of this literature review focused on the aspects of a student-centered classroom. Allowing the student to be at the center of the instruction gives the student the time and space they need to develop and understand the mathematical concept being taught. Davidson (2019) states that for students to be able to understand the mathematical concept, they must be given time to do so. Providing time is equally as important as providing the experiences within the classroom. According to Hiebert et al (1997), students who were given time to explore were more successful in their assessments than students who focused on tasks only, not given ample time to explore the tasks.

Hejny (2012) provides guiding principles for teachers who work within the scheme-oriented classroom, also known as a constructivist or inquiry-based classroom. The guiding principles include first creating an environment where students know that they are not just capable of being successful, but they are successful in mathematics. Success isn’t always defined by the right answer. Mistakes are acceptable. It’s how students learn. Having a classroom where students feel comfortable in sharing their strategies and solutions as well as being able to talk about them is important. Another principle is the importance of guiding discussions or asking guiding questions to help students access prior knowledge and construct new understandings. It is critical to let all students share their strategies. The teacher must validate all responses and lead the discussion, so that all students feel validated. A third principle is to let mistakes happen. When mistakes do happen, give the students time to discuss them, learn from them, and correct them on their own and through the assistance of others. A fourth guiding principle is to be strategic in problem selection. The problems should be accessible for all students, regardless of ability. The students may access the problems at different entry levels; however, they will be able to access and construct new learnings as a result of the class discussions.

"The most basic responsibility of constructivist teachers is to learn the mathematical knowledge of their students and how to harmonize their teaching methods with the nature of that mathematical knowledge" (Steffe & Wiegel, 1992, p. 17). How is this accomplished? Borasi (1992) provides guidelines for creating an inquiry-based classroom environment. First, the teacher must use real-life problems. The problems must be culturally relevant and authentic. Secondly, it is important to create uncertainty through non-traditional approaches or problems. In doing so, the student is not simply memorizing or recalling a procedure. They are focused on the construction of knowledge through their struggle and experiences. The third guideline is to let errors happen. Errors are good. These can be used as launching points for further inquiry. The fourth guideline is critical to the acquisition of knowledge. The teacher must create questions and conflict. A fifth guideline is to promote discussion. As the standards created by the

NCTM (2000), discourse is imperative to students being able to not only perform mathematics, but to speak mathematically as well. Lastly, the students must be given time to reflect both personally and with their peers.

The purpose of this section was to provide insight into key components required to incorporate a successful inquiry-based classroom. These components, along with the utilization of the information provided in previous sections, will allow educators to enter into the world of inquiry-based learning in their classroom. In the upcoming chapter, greater detail will be provided in how to create a math unit. This will include all of the stages from planning to assessment.

Summary

The research reviewed in this literature review focused on inquiry-based learning and instruction, and it answered the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?* In this review, three themes were identified. The first theme defined inquiry-based learning and the importance of inquiry for student engagement and learning success. The second theme presented research and detailed studies showing the effects of inquiry-based learning and instruction on student engagement and success. In this section, much of the research supported inquiry-based learning through the use of the theory of constructivism. The last theme described inquiry-based pedagogy. Strategies were provided to implement successful instruction. The intent and focus for this literature review was to emphasize the benefits of inquiry-based instruction to increase student engagement. As the research presented mainly provided the history and benefits behind inquiry-based learning, there are educators that don’t feel that inquiry-based learning is the most effective. Arguments have been made for the benefits of teacher-centered, direct instruction to help children succeed in mathematics. As I reflect upon my personal experiences as a student and a teacher, I have found the most engaging way to learn is to learn by "doing" and to learn by exploring. This is done through developing an understanding of the concept, not just memorizing. Memorizing will enable a student to be able to solve problems specific to what they have memorized. Understanding will enable a student to solve a problem that they have not been presented previously.

In Chapter 3, the project based on this literature review is described. The project is the design of a curriculum unit for math instruction in a third grade classroom. This project will provide a detailed plan for creating and teaching an inquiry-based math unit. Utilizing the knowledge gained from the literature review will enable the creation of a math unit where 1) students are given the space, autonomy, and freedom to inquire, and 2) educators are given questions to ask and guidance for how to facilitate, assess, and scaffold the students to the next stage in their math journey.

CHAPTER 3

Project Description

Introduction

In Chapter 2, the research presented supported the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in the third-grade classroom?* When starting this research, it was my intent to create an inquiry-based math curriculum unit. Within the unit, there would be inquiry prompts as well anticipated strategies and methods for the educator to provide an engaging lesson for the students. The objective was to transform my methods for teaching math, breaking away from traditional, teacher-directed methods described in Chapters 1 and 2 of my paper. I think that many educators share the same experience of direct math instruction in their school years. There is a procedure or algorithm that is taught. The students are then given multiple problems, so that they can show that they can repeat the procedure and solve the problem correctly. Although my objective for this project has not changed, after reviewing my research and reflecting on another year of teaching math and science to third graders, I now realize that a new curriculum is not what will enable me to accomplish my goal of increasing student engagement and learning in an inquiry-based classroom. Companies have spent countless hours creating effective curriculum materials, focusing on providing educators with quality tools for teaching. I feel that the curriculum used in my school, Math Expressions, is a very effective curriculum. In fact, it focuses on math "talk" and thinking about problems; however, I don't feel that the curriculum allows the time for true inquiry. What I realized is that I need to utilize the curriculum given and build upon it to meet my goal of increased student engagement and learning as a result of inquiry-based instruction. By focusing on the pedagogical theories referenced in previous sections of this paper, I need to create something for educators to support the lessons and curriculum we are given. More specifically, my project is the creation of a website that provides guidance, strategies, and methods to not only teach with inquiry, but to create a classroom that promotes inquiry. I believe that if we, as educators, can create an environment where students feel and hear their voice in everything they do and say, engagement and long-term learning increases. With this website, I, as well as my colleagues, can then enhance the district's curriculum to ensure my students are at the center of the classroom. The students are the focus. In addition to describing the project, I provide the rationale for the project, the platform used, the content, settings and participants involved, the timeline, and the evaluation and assessment criteria.

Rationale

As described in Chapter 2, inquiry-based instruction helps increase student engagement and long-term learning success. Specifically, Gialamas et al (2001) state that guided inquiry, which is what this project focuses on, encourages students to be active learners in their education. Furthermore, it focuses on the benefits for the student beyond the immediate acquisition of the concept or procedure. When doing so, they are able to go beyond the mathematics world and into their everyday world, making the math and learning more meaningful (Gialamas et al, 2001).

Before inquiry-based instruction can be implemented, the students must first believe in themselves as mathematicians. They must perceive and believe that others, peers and their teacher, sees them as mathematicians. As an educator, when students are asked what their least favorite class is, oftentimes the response is, "Math". Students grow up learning and understanding that there are math people and not math people. Their confidence in mathematics is challenged because of these preconceived notions. In an article written by Schwartz (2015), Boaler describes the importance of negating these thoughts early in the children's learning. Through extensive research of the brain development and teaching of mathematics, she describes that there is no such thing as a "math person". On her website, www.youcubed.org, a video describes the following for every human being.

1. There is no such thing as "smart people" and "not smart people". There is no such thing as a "math person".
2. When you believe in yourself, your brain works differently.
3. Mistakes grow your brain.
4. Speed is not important. It is important to think deeply and creatively.

I have experienced these same conversations in my classroom. For this reason, I focused my instruction, first and foremost, on helping students understand and believe that they can be mathematicians. Building that confidence becomes possible when students are allowed to access their learning at different entry points. Through inquiry-based instruction, students are given one problem or question. They are then allowed the autonomy to work with the question using the prior knowledge they have. Through math conversations and inquiry, students are able to discuss their strategy as well as hear from their peers. The learning extends beyond the memorization of an algorithm. The learning extends beyond *practice makes perfect*.

In my research, I write in detail about the attainment of mathematical concepts. As educators, we talk with our students about "Grit". Oftentimes, there may be problems that students don't feel are necessary. It's in these problems where students develop the skill of problem-solving, a skill that is needed throughout life, not just in mathematics. Another concept that students develop in school is the perception of self, or self-efficacy. As an educator, it is my goal that students are given every opportunity to live out their dreams, to do what they want to do. They need to know that they can. We can help them get there. Educators can use this website to obtain tips, tools, and strategies to set up their classroom for this inquiry-based learning environment.

After I have created an environment where students believe in themselves and are confident in their voice, I then move onto the next step of inquiry-based instruction. I need to set the stage through a state of wonder. That can happen in many different ways. Typically, with inquiry, students are given the following questions: *What do you notice? What do you wonder?* Students are then given time to explore. They are given time to talk through their problem solving with their peers. These questions are not bad questions. They will get students thinking and talking, which is one of the goals of inquiry-based lessons. In this project, I provide suggestions for asking different questions, perhaps even more relevant questions. *What is wrong with this image? How might you see this differently than someone else? Why does this matter, or does it?* I even ask the simple, yet complex question, *What do you think?* If we go beyond the easy questions and ask more challenging ones, students will become engaged more quickly. If they are engaged, they will then be more likely to stick with the lesson and develop conceptual understanding.

Framework and Content

When I first came up with the idea to create a website, an immediate panic came upon me. How do I do that? In my research, I found that there are many platforms that can be used. Some are free. Some cost money. Some are a hybrid of both, depending on how you want the site to be named and recognized by users. Based on a review of previous websites utilized by educators, I chose the website platform Wix. First and foremost, as an educator, the cost of materials and supplies can be challenging. I looked to utilize a free website creator, and Wix was my winning choice. Furthermore, I found that the templates offered in Wix were easy to use. As I spent more time exploring the website, it became easier and less daunting. I feel that I must add that I originally created a website using Google Sites. This website platform, like Wix, is free; however, I felt it was limited in its features.

Now that I had selected my platform, I needed to create the content. My first task was to decide what the name of my website would be. I decided to name my website, MathMINDS Unlocked. I chose this intentionally, as I referenced Jo Boaler's research in Chapter 2. We are not born *math people*. We can learn how to become *math people* if we unlock our beliefs, or disbeliefs, that we can or can't "do math". In my website name, I included a logo of a lock that is open. I wanted to create a logo that 'sticks' with the end-user. Once I had determined the name of the site, I needed to research what made a website effective. One of the most important factors in creating an effective, easy to use website is the ability to navigate seamlessly. Visitors need to easily find what they are looking for (Kosloski, 2016). The navigation bar is a slide-out menu that runs vertically. It includes the following sections:

- Home
- About
- Find your "Why"
- Inquiry-Based Instruction
- Sample Lessons & Templates
- Contact
- About Me
- Blog
- References

These navigation tabs are also found on the bottom right of each website page. In addition to these tabs, I have created three buttons, Mission, Get Started, and Share. These three buttons send the end-user to tabs listed above (About, Inquiry-Based Instruction, and Contact, respectively).

The content in the website provides guidance on what inquiry-based learning is, why it is important, and how to incorporate it into a classroom. Although I am not creating a new curriculum, the strategies given in the website are entry points within a lesson. How these strategies are used will determine how effective they are when teaching the lesson. These strategies given are intended to transform the lessons that are being taught. That being said, it is important to understand the foundation and framework of a lesson that encourages inquiry-based learning. To help with the creation of my strategies and methods, I researched the Understanding by Design lesson framework by Wiggins and McTighe (2011).

The first step of *UbD* is to determine the concept that students need to learn. Wiggins and McTighe (2011) state that it is important to start with the "big idea". This first step supports inquiry-based instruction. The instruction and learning are not about knowing and practicing the method. In a traditional classroom, the algorithm memorization and practice determine the outcome and if the goals and objectives of the lesson are met. With inquiry-based instruction and *UbD*, the development and realization of the algorithm comes much later in the lesson. With both methods, there are standards that must be met. How those standards are met are different. With the inquiry-based and UbD methods, students spend more time exploring the concept which leads to a greater, long-term understanding. Wiggins and McTighe (2011) state that the desired results of the UbD framework is to ensure students understand what they have learned. In addition, they can transfer their learning and understanding to new situations. This is so important in math instruction. When you think about solving real-world problems or scenarios, outside of school, oftentimes, you don't use a specific method. You use a concept. That is what is important - the understanding. Wiggins and McTighe (2011) make the connection of coaching as one of the eight tenets of *UbD*. In Chapter 2, I focused on the importance of being a facilitator and coach throughout the inquiry lesson. Another term used in *UbD* is *authentic*. Wiggins and McTighe (2011) write about the importance of being authentic when creating and executing an inquiry-based lesson. They state the need to ask essential questions. The questions must be authentic and relevant to the students being taught. In my website, I offer strategies to first set up your classroom environment, so that students feel comfortable and confident sharing their thoughts openly. Before you can expect students to be authentic, as an educator you need to show that you are authentic.

To enhance my website content, I utilized two resources. The first is the curriculum used in my district, Math Expressions. There are five core structures of Math Expressions. They are as follows: Building Concepts, Quick Practice, Math Talks, Student Leaders, and Helping Community (Math Expressions, 2018). There are components within this curriculum that correlate with inquiry-based learning. The second resource is a book written by Boaler. Munsun, and William titled *Mindset mathematics: Visualizing and investigating big ideas, grade 3* (2018). This book focuses on much of the research previously written about in this paper. It provides sample activities and lessons that promote inquiry in the classroom.

Where inquiry enters the lesson is how the educator leads the lesson. It is in this phase of the lesson that the *UbD* framework becomes critical. I recently participated in a professional development workshop focused on transforming lesson planning specific to math instruction. Like Wiggins and McTighe, Kiebler (2021) talked about the importance of starting at the end of the unit. Creating an effective unit starts with determining the concept that students need to learn. The goal is not to ensure students can recall procedures, but instead understand important ideas and transfer learning to new situations (Wiggins and McTighe, 2011).

Settings and Participants

The website has been created for educators in a suburban district outside of a major midwestern city. The school consists of approximately 500 students in grades K-4. This website is created specifically for a third-grade classroom; however, it could be adapted to fit the needs for other grades as well. The activities will change; however, the foundation of building an inquiry-based classroom and providing educators with strategies to do so remains the same. The population of this school, inclusive of the students and staff, is primarily white/Caucasian. That being said, this math unit and type of instruction would be successful in many different environments. According to Riegle-Crumb et al (2019), inquiry-based instruction provides an equal opportunity for everyone. In a sense, it levels the playing field and removes the ideas and stereotypes that a certain gender or race are not as successful as others. Based on this research, I feel that this website can be used as the basis for education in any content area. Inquiry-based learning is applicable across education. This website can be used as the catalyst for classrooms at all age levels.

Evaluation and Assessment

Success will be defined, first and foremost, in the completion of the project this summer. I will be collaborating with my colleagues in my school. Gaining the support from my colleagues as I look to enhance math instruction will be critical in the creation of this website. Once the website has been created, it is my intention to review it with my colleagues and administrator.

The assessment and success of this project will be completed using two methods. The first method is to receive feedback from my colleagues. Ease of navigation, incorporation of strategies, and feedback involving those topics will determine how effective this website truly is. Secondly, one of the best ways to receive feedback on accessibility is through the use of a blog. In addition, I have a contact page where end-users can provide feedback or ask additional questions. Both of these will generate interactivity with the end-user (Kosloski, 2016). As educators and life-long learners, this is critical.

Project Timeline

The website was created during the summer of 2022. The website will be shared at the beginning of the upcoming school year. I will share this with colleagues not just in my school but throughout the district. Because of the *Contact* and *Blog* sections created in the website, I envision the timeline to be infinite. The purpose of this website was two-fold. First, I wanted to provide educators with a platform to find ways to incorporate inquiry-based learning in their classroom. Secondly, I want the website to be interactive. With this, I will utilize strategies and methods to create an inquiry-based classroom throughout the 2022-2023 school year and beyond.

Summary

The website, MathMINDS Unlocked, was created in relation to the research conducted to support the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in the third-grade classroom?* Through the use of this website, I will be able to further develop and continue my inquiry-based instruction journey. In addition, the website provides other educators to learn the power of inquiry themselves. The website not only provides examples of inquiry-based learning activities, but it focuses on first creating a classroom that promotes curiosity and inquiry. With this, it is my hope and goal to make my math instruction more meaningful and help my students become life-long problem solvers. In Chapter 4, I provide a reflection on my research. Specifically, I revisit the literature review, emphasizing literature that both supports my research as well as challenges my view point. I feel strongly that research that may disagree with my position is imperative to learning. It is that conflict and discourse that creates more knowledge. In addition, I reflect on the process of conducting my research, creating my project, and writing about it. Lastly, I provide insight as to how this research and project will be used to not only improve my role as an educator, but how it will be shared with my colleagues and future educators helping to answer the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in the third-grade classroom?*

CHAPTER 4

Conclusion

Introduction

The purpose of this capstone project was to research and explore inquiry-based instruction. My goal was to answer the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?* As I described in Chapter 1, I grew up learning in a teacher-centered classroom. As an educator, I see many of my peers teaching in this manner. With that, I found myself to be exceptional at memorization. If there was a formula to memorize, I could do it. That being said, I was not developing problem-solving skills. I relate this to a time when I was in pharmaceutical sales. I won many awards during training because I was given specific things to say - specific scripts. When role playing, I was one of the best. My manager told me what to say. I practiced. I showed mastery. Unfortunately, when I encountered doctors in a real-life, fast-paced environment, I struggled. I was taught to memorize. I was taught to execute. I wasn't taught to problem solve when things presented themselves differently. Now that I am a teacher, I have seen how much more effective instruction and student engagement can be if they participate in the instructional and learning process. This is where inquiry comes into play. In the upcoming sections, I will reiterate the significance of inquiry-based learning for our students. This chapter describes major learnings from my journey throughout this project, a return to literature emphasizing the importance of an inquiry-based classroom, the project impact, and the next steps.

Major Learnings

When I first envisioned my project, I wanted to focus on math instruction only. Much of my research in Chapter 2 is based on math instruction. That being said, while reflecting on my research, I discovered that my project didn't need to focus just on math content. I wanted to focus on the general concept of inquiry-based instruction and learning across all content areas. Because of this change in my thought process, a shift in my final project occurred. My project was originally designed to focus on instruction only. My goal was to gather as much information as possible on the importance of instruction and how it impacts learning. I found so much more. I was able to research the learning piece of an inquiry-based classroom as well. Prior to my research, I was going to create a math unit which would include 3 weeks of lesson planning. After many discussions with my instructor and peers, review of the literature, and reflection, I realized that the curriculum didn't need to be changed. Companies do extensive research to provide curriculum for teachers. Instead of recreating the curriculum, I wanted to enhance it. This is where the project shift came. I wanted to provide a website that provided background information on inquiry-based instruction and learning, why it matters, and resources to incorporate it into your classroom. Creating an inquiry-based classroom is much more than just asking questions. It starts with creating a community where your students feel safe, where vulnerability is not only accepted but encouraged. When you have these attributes in your classroom, inquiry-based learning can be implemented much easier.

Personally, I learned a lot about how it feels to be a student. I talk with my students about *grit*. I talk with my students about pushing beyond what they think they are capable of. I talk with my students about being vulnerable. I was now the one that needed *grit*. I needed to be vulnerable. At times, this was not easy to do. This project required more determination, focus, and *grit* than I had ever imagined. I believe that there are easier programs out there. That being said, I feel so fortunate that I chose Hamline University to obtain my Masters Degree. My educational experience at Hamline University is what formed my view on inquiry. In every class that I participated in, there was always space to question. Every class was student-centered. Every class offered a space to challenge myself and get outside of my comfort zone. It wasn't always easy. That being said, I did it. I was able to overcome the stress and anxiety. I was able to prove to myself that I know how to research, and I can become a good writer with practice. In addition, this project has allowed me to make a personal connection with my students on a deeper level. I now know how they are feeling when it's too hard or they are too tired, and they feel like they just can't do it. It's true that the best way to understand how your teaching impacts others is to experience what your students are experiencing. This experience has made me stronger, both personally and professionally.

In the next section, I return to my research and all the fascinating literature on the benefits of inquiry-based learning and instruction.

Return to Literature

What I found most fascinating about the literature I reviewed is how much more information is available than what I found. One of my classmates is researching a similar topic. Their research was focused on inquiry-based learning through math word problems. As I reviewed their paper, I did not find one resource that I had used. What that showed me is that inquiry-based learning is something that is relevant. It is something that has been researched for many years and continues to be researched today.

The importance of inquiry starts early in our students' educational journey. Boaler et al (2021) describes the necessity for allowing students to explore, especially in their younger years. Her experience is that too often students are being taught to copy and use methods that the teacher uses and teaches. Students are not allowed to use their own methods. They aren't allowed to be curious and ask questions. For these reasons, students lack engagement in math because they are not allowed to think independently. They are not allowed to use their experiences or prior knowledge. Carpenter and Lehrer (1999) state that talking is not just important, but it is a benchmark of understanding. Inquiry is critical to a students' development and engagement in mathematics.

The importance of inquiry-based learning is widely documented. The National Council for Teaching Mathematics (1989) states the following goal of mathematics in schools today, which support the importance of the change in mathematical instruction and learning: In order for students to make sense of mathematics in their own terms, they must take mathematical actions: represent their ideas, make conjectures, build models, collaborate with other students, and give explanations and arguments. Inquiry-based learning provides students the opportunity to learn in a cooperative classroom setting. Cooperative learning is imperative in an inquiry-based classroom.

Hejny (2012) describes three goals of children's cognitive development in mathematics. The first is that the student understands mathematics. They are not just a "human computer" pumping out answers. Children's learning is more effective when they are able to fully-understand what they are being taught. Inquiry-based learning enhances critical thinking skills, makes learning more interesting, encourages curiosity, empowers students, and enhances comprehension (www.wabisabilearning.com, 14 June 2021). The second goal is that students are motivated to do math on their own because they are engaged, not frustrated. When students learn passively, they become disengaged and often stop learning mathematics as soon as they can (Boaler & Greeno, 2000). The third goal is that students develop globally in math. Specifically, students are able to explain their solutions to problems, they are working collaboratively with others in class, and they use what they know to solve something they don't. Lastly, they are given time to investigate their errors, so that they can learn and overcome misconceptions as well as correct their errors.

Children today are introduced to formulas and algorithms before they are cognitively ready to be introduced to alogrithms or procedures. Oftentimes, this leaves them confused. The inquisitiveness of children's early years fades away and is replaced by a strong belief that math is all about following instructions and rules (Boaler, 2015). Creating a classroom environment where students are shown an image or given a problem, but instead of being told what strategy to use to solve it, are instead told to come up with ways they think would work for the solution, is a classroom that supports inquiry-based instruction and learning. It is a classroom that doesn't simply teach the procedure and teach students how to compute.

In order for our students to truly understand what they are learning, they need to ask questions, challenge each other and themselves. They need to wonder. They need to notice. They need to explore. This is the foundation of inquiry-based learning and instruction. This is how students become excited about mathematics. They begin to realize the importance of solving math problems, not just memorizing math solutions.

Inquiry-based learning is not accomplished by accident. The educator's facilitation of the classroom is purposeful. It is imperative that the teacher sets the stage for the class. They must pose a question or problem and allow students to be able to explore, construct, and reflect on the problem-solving process. The teacher must be ready, have guiding questions, and design the learning experience, so that students can engage and learn to become explorers in mathematics (Richards, 1991).

In the next section, I describe how this project has impacted me as an educator today. I also describe how it will influence my teaching pedagogy as I enter my new role as a 5th grade Social Studies and Science teacher.

Project Impact

When I think about the project impact, I think of two specific places in time: *Now* and *The Future*. An impact has already been made. Prior to this project, I wanted to experiment what it would be like to try project-based learning. I had tried to implement it a couple years ago in my 6th grade Social Studies classroom. It was a step in the right direction, but there were critical steps that I missed. Overall, the students experienced what a student-centered classroom looks, sounds, and feels like. That being said, there were specific goals and timelines that were not met. By completing this research and creating this website, I now have a better understanding of what inquiry-based instruction is and how to make it a part of my pedagogy. I am energized. I can't wait to share my project with my peers and my administration. Furthermore, I can't wait to use the strategies I have included in the website for my classroom. It will be a year of growth for me as an educator.

In the near future, I hope that I can share this website with my building. I envision this to be part of a professional development day. It is my hope that this website is not a *'one and done'*. I would love to have conversations with educators about the website and its content. I will encourage discourse. I will encourage inquiry about my website on Inquiry-based learning.

In the following section, I describe what I plan to do with my project and how I intend to share it with others.

What's Next?

I am really proud of the website I have created. I am excited to share it not just with my peers in my school, but with all of the educators in my district. When I first started this project, I was focused on 3rd grade math instruction because math is my passion and I was teaching 3rd grade. This year, I am teaching 5th grade. I am teaching Social Studies and Science. That being said, all the content in my website is applicable to my instruction and learning. I feel that what I have created can be shared not just at the elementary level, but the middle school and high school level as well.

I will start by sharing this with my administration and look for their guidance for next steps. As stated in the previous section, I would love to incorporate this into a professional development day. My hope is that I help create a spark for educators. I hope that this inspires my peers to incorporate inquiry into their classrooms. One suggestion by my content expert was to share on Twitter. As social media is an influence in our world today, my intention is to share this with educators across the country and even the world. The purpose is to receive feedback, suggestions, as well as ideas from other educators. This website isn't perfect. I don't claim to be an expert; however, I think that building an online community of educators who are focusing on making our students the leaders in our classrooms would be very beneficial. This website is just the tip of the iceberg. The conversations and sharing of ideas for years to come is my goal.

Summary

This chapter provided a reflection of my capstone project. Furthermore, it summarized my purpose of the project which was to answer the question, *How can the implementation of inquiry-based math instruction increase student engagement and learning success in a third grade classroom?* I revisited literature describing the impact of inquiry-based instruction and learning, described the project impact and next steps not only for the project but for me, as an educator. Throughout my experience completing this project, the numerous conversations I've had with educators, and the early feedback of my website, MathMINDS Unlocked, I feel confident that I have answered my research question and look forward to seeing the impact in my classroom and beyond..

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