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Inquiry-Based Learning and Growth Mindset In Third Grade Mathematics

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INQUIRY-BASED LEARNING AND GROWTH MINDSET IN THIRD GRADE

MATHEMATICS

By

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A capstone submitted in partial fulfillment of the requirements for the degree of
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CHAPTER ONE

Introduction

As an educator, there is hope to give students the space to be curious and become lifelong learners. We have nine months with our students to help them learn and grow. Every year, I ask myself, “What do I want students to get out of being in my class?” This is something that all teachers should think about. When I reflect on my educational experiences, the teacher made or broke the experience that I had. I know for myself, I want my students to be curious about the world and become lifelong learners. The question is, what is the best way to help students to become individuals who always want to learn more?

Mathematics is a subject that was challenging for me in my educational experience. I always felt that if you got an answer wrong, you were therefore bad at math. If I did poorly in a mathematics class, I felt that I was not a math person. An issue with the way mathematics is taught is that students are trying to get a correct answer. I had very few experiences in my education where I was given opportunities to reflect on the why. The way mathematics is taught is to teach a strategy. The student then practices that strategy and is then tested on it. The problem with this is, then students may not understand the procedure and the mathematics behind the problem. I know adults who to this day still think they are “not a math person.” This fixed mindset behind mathematics needs to change. The way we change this fixed mindset is to alter the way that mathematics is taught.

A possible solution to change this fixed mindset around mathematics is to teach the subject using inquiry-based learning. This type of learning allows students to be

curious and develop critical thinking skills. Inquiry-based learning is a more hands on approach to learning math. The way we teach our students will determine what a student gets out of our class. All educators want their students to grow and be a part of who they become after leaving your class. My research question is: *How can inquiry-based learning in Elementary mathematics help create a growth mindset?*

After reflecting on my math experiences, I realized that the reason for me thinking I wasn't a math person had to do with the way I was taught math. It was not until high school and college where I had positive experiences in a math class. I really think that if we change the way we teach mathematics, we can help improve negative feelings about the subject. Inquiry-based learning is a hands on learning approach that is open ended (Dickson et al., 2017). From my experience, when I was more involved in the math process, I started to feel differently about the subject. That involvement also helped with my confidence in the subject area.

In this chapter, I will discuss how my experiences have guided me to researching this area. First, I explain my mathematical experiences in my K-12 education. Next, I discuss how I teach mathematics to my third-grade class. Then, I explain how I would like to teach mathematics. Finally, I explain the rationale for the research. All of these have helped me find my passion for how math should be taught in the classroom.

My Mathematical Experiences

School was always a challenge for me. I felt that math was very difficult. I never saw myself as a “math person” until I became an adult. I hear other adults reflect on their math experiences negatively. They think that they are bad at math. There is a problem with the way math is taught to many of us. For most of us, math was centered around testing instead of questioning and the meaning behind the mathematics. I also did not have many opportunities to investigate or explore my mathematical ideas.

As I reflect on my mathematical experiences, I realize that a lot of my experiences were shaped by the teacher that I had. Most of my math teachers centered learning around testing and memorizing a formula. I had very few teachers who gave us the time to be involved in the learning process and ask questions. I remember attempting to memorize equations to get ready for a test. There were very few times in which I thought critically about the process of what I was doing in class. I think that if I had been given an opportunity to make this reflection, I would have had a growth mindset towards mathematics throughout my education.

If my seventh-grade math teacher knew that I was a teacher and writing about mathematics, she might be surprised. She was one of the few teachers I had who provided positive experiences in mathematics. They were the first teacher I had where I saw a growth mindset mentality. My seventh-grade math teacher inspired me to always try my best and not to become fixed in my ability to do math. I had a very challenging time in seventh grade. She called tests learning celebrations. They would play the celebration song and have us dance to the song before we took a test. She would tell us a test is a celebration of all the things we have learned. Testing was then seen as a more positive

thing. We reflected on our test results and thought about how we could do better the next time. This process allowed me to be able to track my progress and have a better mindset on how I was doing in class. Although this class was difficult for me, it allowed me to have a more positive mindset around mathematics than I had never had before.

Most of my math classes were very independent. I did not have a lot of opportunities in which I got to work in a team. I remember feeling very alone in many math classes and scared to ask for help. My tenth-grade Geometry class was the class in which I felt the most isolated. I think that Geometry is a subject that students could really benefit from working together. The teacher I had for this class was not involved in our learning. We were mostly on the computers by ourselves. I did not feel supported by the teacher at all. I remember feeling so overwhelmed by all of the vocabulary and applying it to the problems. Looking back, I had a fixed mindset during this whole class. I constantly felt defeated. I felt that I was not a math person. If I would have been given opportunities to explore and ask questions, then maybe my experience with Geometry would have been different. To this day, that class has made me feel that I am not the best at Geometry, which in return, affects my teaching of it. If I had been given more engaging activities or involved in my learning process, I think that I might have had a better understanding of Geometry. Inquiry-based learning allows students to be involved in the learning process. That would have been very beneficial for my Geometry experience.

The year after Geometry, I took Algebra with an amazing teacher. I really thrived in Algebra because it clicked with me. I loved the solving of the equations and graphing. My mindset towards math started to shift. Now, I could see that maybe I was a math

person. My Algebra teacher gave us opportunities to work in teams and question what we were doing. The way in which math is taught and the teacher truly impacts the mindset students have towards mathematics.

After reflecting on my math experiences, I realize that a lot of my experiences were shaped by the teachers that I had. When I had a teacher that showed care for their students, I did better in my math classes. This connection to others is so important in our success as a student. I also noted that I had more positive experiences with math when I was challenged by the process. For example, my Algebra teacher allowed us to work in teams and explain our thinking. It is important for students to understand and to question what they are doing. In return, they will be more involved in their learning and have a growth mindset towards mathematics. Any experience in which I as the student was involved in the process, led me to feel the strongest success. When students feel like a part of the process, it helps them feel ownership in their learning as well as lifelong learners. My teaching mathematics course in college was the first time I experienced learning through inquiry-based learning. I remember being pushed in ways I never had been before. It was challenging, but I also felt empowered and confident in my math ability.

How I Teach Mathematics

My main goal when teaching math is to create an environment in which students understand that mistakes are okay. Math is a subject that can be difficult if you get an answer incorrect. If a student comes up to the board and solves a problem incorrectly, we talk about other ways that we can solve that problem. This also gives students the space to explain their mathematical thinking. I make mistakes too, which is important for the

students to see. Everyone needs to understand that we all make mistakes. These mistakes allow us to think deeper into what we are doing.

Throughout my math lessons, the students participate in turn and talks. Each student has a specific partner that they talk to. With their partner, they explain how they just solved a problem. During this time, I go around to students to listen in on their discussions. Sometimes I will push them further with other questions. This is a critical time for them to have math talk and explain their thinking. After they have finished their discussion, we reflect on what they discussed.

During my after-school math class, I taught second and third graders. Part of our routine was Dot Talks. This math routine allows students to quickly look at an image that has dots grouped together. The challenge is to try to figure out how many dots there are. After they were given a few opportunities to see the dots, they shared the strategy they used to figure out how many dots they saw. I found this to be a very beneficial activity for students. I felt that it helped to improve their number sense. It also helped to improve in expanding their ability to explain their thinking. Something really powerful about doing Dot Talks or Number Talks is that it gives students opportunities to explore their own thought process. I saw a light bulb go off for many students when another student solved a problem in a different way, or the excitement when someone may have solved the problem in the same way. Giving students the space to explain their thinking, helped them gain confidence in their ability to do math. It is clear that math routines like these are very beneficial to students.

A strength in my teaching is questioning. I ask students questions to check for their understanding and to push their thinking. I find it valuable to give students

opportunities to explain. Math talk is something that is very important to me as a teacher and as a learner. These conversations enhance our learning, as well as help teachers to understand where a student's progress is. However, an area that I want to grow in is giving my students more opportunities to investigate and ask questions about why things are done the way in which they are.

Last school year, my team did some math growth mindset activities at the beginning of the year with our third graders. Students were given opportunities to work in teams and investigate mathematics through inquiry-based learning. At the time, I remember thinking that these activities might have been confusing for students. Looking back, I now realize as a teacher that it was hard to give students these kinds of opportunities because they were very different than what we did day to day. These investigating activities are very important when teaching mathematics. After some reflection, I wish I would have brought this kind of thinking into our other math units. This is a big goal that I have for my future teaching.

How I Would Like to Teach Mathematics

Through this reflection process, I have been thinking about the changes that I would like to make in regards to how I teach mathematics. I know that I want to try to incorporate inquiry-based learning more into our math units. The beginning of a math unit seems like a good place to give students these opportunities. I also think that doing these types of investigative activities at the beginning of the school year can help set the stage for the rest of the year. The most important thing is consistency with inquiry-based learning throughout the school year.

I want to continually implement growth mindset activities in mathematics throughout the year, and not just have it be something sprinkled in at the beginning of the school year. The growth mindset activities at the beginning of the year would have had a larger impact on students if I continued to have that type of learning throughout the rest of the school year. I would also like to have monthly activities with growth mindset activities. During these activities, students can reflect on their mindset towards mathematics. Within these growth mindset activities, it is also important to give students time to reflect and track their progress in regard to how they think about mathematics. I think that the more involved students can be in the process, the better.

Overall, the way that I want to teach math is for students to have opportunities to be involved in the learning process. I want students to be able to take ownership of their learning through the investigation process. Throughout this process, I would also like to give students more opportunities for hands-on activities. With these hands-on activities, students could work in teams. The math would be more meaningful to students if they are actively involved in the learning process. In these hands-on activities, students would be able to investigate and question what they are learning.

Teamwork is another important aspect of teaching math through inquiry-based learning. I want to find more opportunities for students to work together. Yes, I currently have students work with a partner where they discuss strategies, but I want to do more. Working in teams has many advantages for students. Working in teams allows students to learn other perspectives and learn new strategies. Which would help them to better understand math. The “we are a team” mindset will help build confidence in students, and hopefully get them to have a growth mindset towards mathematics.

I continue to push students' thinking by asking them questions. I now realize that I do not always give them the same opportunities. I push their thinking by asking them the questions, but I do not always give them the space to be the ones asking the questions. Moving forward, I want the students to be the ones asking the questions and investigating why things are the way they are. This could be done while doing investigations in teams, or in math lessons. I would model this type of thinking while teaching. Allowing students to take ownership of their learning through inquiry-based learning would bring more meaning to the math they learn but most importantly, would allow students to learn to love to learn.

Rationale for Research

A goal for most educators is to help students become people who want to be lifelong learners. Teachers tend to have this mindset that we are always learning and trying to improve. The way that we teach will have an impact if students have this mindset about learning. I believe that incorporating inquiry-based learning in mathematics would help students have a growth mindset and increase their problem-solving skills. These two attributes to school would help students have the belief that we are all lifelong learners.

I have heard too many students or adults say that they are "not math people." The way I learned math creates a fixed mindset towards mathematics. If students are more involved in the process through curiosity and investigation, it will change their mindset towards learning and most importantly, mathematics. I believe that the way in which we are taught helps shape us as individuals and our feelings towards learning.

Giving students the space to question and investigate will bring more meaning and purpose to their learning. When math is taught as just memorizing a strategy, and then getting tested on it; there is no meaning towards the learning. If you do not do well on that test, it creates this mentality that you are not good at it. Inquiry-based learning in math allows students to have opportunities to question the process and strategy that they are learning; instead of just memorizing an equation.

After reflecting on my mathematical experiences and how I teach math, I find a shift in how we teach it to be crucial to our students' success in mathematics and in life. The experiences that students are given in their education help shape them as individuals. Therefore, it is very important for educators to reflect on the way that they teach and to try to create a change.

Summary

My overall goal of this research is to provide a different experience for my students in their mathematical journey. During the reflection process, I realized that some of the ways that I currently teach math are similar to the way that I was taught math. Those teaching strategies can lead to a fixed mindset towards mathematics, which I want to change. I want every student in my class to see themselves as a mathematician. Inquiry-based learning will lead to students who have problem-solving skills and a growth mindset towards learning. This purpose leads me to my research question: *How can inquiry-based learning in elementary mathematics help create a growth mindset?*

Chapter Two will be my research design. In this chapter, I will analyze and summarize the current research around inquiry-based learning in mathematics. My goal is to fill the gaps within the current research. A subtopic that I will be researching is current

strategies for inquiry-based learning in classrooms. Within that topic, I want to research best practice for embedding this type of learning into the math curriculum. Another subtopic that I will research is the best practice for the continuation of growth mindset activities throughout the school year. Chapter Three will include my project description. Chapter Four will be my reflection and conclusion.

CHAPTER TWO

Literature Review

Introduction

In Chapter One, I reflected on my past educational experiences both as a student and a teacher. Unfortunately, I and many others have experienced negative math education, which is harmful to individuals and how they view the subject. I discussed how I currently teach math and how I want to change the way I teach it. Due to my math educational history and how I teach math, I see there to be a call to action in how we teach and view mathematics. I would like to know *how can inquiry-based learning in elementary mathematics help create a growth mindset in students?* Many students think they are not “math people” due to their negative experiences with mathematics.

Inquiry-based learning allows students to be more involved in the learning process. When students are given these opportunities, the hope is they will have a more positive outlook on mathematics.

Chapter Two will focus on many themes within my research question. The first theme is inquiry-based learning. In that section, I explain the many important aspects of inquiry-based learning. The next theme is teamwork in inquiry-based learning. Collaborative work is an important aspect of inquiry-based learning. It is important to discuss the role that both teachers and students play in this type of learning. In this section, I also discuss student challenges and success from working in a team. After I discuss teamwork and inquiry-based learning, I will make the connection to math mindsets. In that section, I provide background information to math mindsets and go into how they are formed as well as the impacts it has on students’ success, specifically in

mathematics. The last theme in Chapter Two is the advantage to having an inquiry-based math classroom. In this last section, I make the connection between inquiry-based learning and students' math mindsets.

Inquiry-based Learning

Inquiry-based learning is a powerful tool teachers can use to teach mathematics. In this section, I explain the background behind this strategy, as well as how to integrate it into the elementary math classroom. It is also important to address the challenges that students and teachers may face with inquiry-based learning. This is a type of learning that not many teachers have experienced throughout their education, therefore it may make them uncomfortable. This type of learning may also be challenging for students due to their lack of exposure to this type of learning. Within inquiry-based learning, it is important to understand the use of questioning that both teachers and students must use. Questioning plays a significant role in inquiry-based learning. Lastly, I will discuss how inquiry-based learning can further help students' understanding of mathematics. It is crucial for students to understand the procedures they are doing. Inquiry-based learning will lead students to have a deeper understanding of mathematics.

Background

In a classroom using inquiry-based learning, about 60 percent of class time is dedicated to students working in small groups, whole-class discussion, student-centered activities, and student presentation of problems on the board. In comparison, in a classroom not using inquiry-based learning, the teacher was talking to the class 85 percent of the time (Kogan et al., 2014). Inquiry-based learning was created to shift from telling students what to know, to creating the type of learning environment where

students were given opportunities to think like a mathematician (Dickson et al., 2017). Students are at the center of the learning process through inquiry-based learning. The teacher takes a backseat and gives more control to the students (Acar & Tuncdogan, 2019).

In 1910, Dewey saw inquiry as a strategy for teaching science. Dewey continued for many years to encourage educators to use inquiry-based learning (Alston, 2016). The purpose of creating inquiry-based learning was to get students more engaged in the learning process, rather than just memorizing facts and procedures (Alston, 2016). Inquiry-based learning was designed to give students more choice in what they learn. This choice helps empower and motivate students to learn (Dickson et al., 2017).

Inquiry is an open-ended teaching approach. It combines real-world situations, standards, and the learning process. Through this type of learning, students are able to apply prior knowledge and creativity to new learning. It also allows students to be curious while also making connections to curricular content. Prior knowledge is an important aspect of inquiry-based learning. The open-ended task helps students make a connection to the math they already know to the developing mathematical tools (Dickson et al., 2017).

Supovitz, Mayer and Kahle (as cited in Marshall et al., 2009) defined inquiry-based learning as, “A student-centered pedagogy that uses purposeful, extended investigations set in the context of real-life problems as both a means for increasing student capacities and as a feedback loop for increasing teachers’ insights into student thought processes” (Supovitz, Mayer & Kahle, 2000, p. 332). Inquiry-based learning allows students to make connections to the real-world through mathematics through

engaging lessons. This type of learning also will help teachers better understand their students' thinking processes as well as their understanding (Marshall et al., 2009).

A constructivist learning environment is the foundation of guided inquiry. Within this environment, teachers need to use observational skills to help them teach and assess students. They also need to pay attention to when new learning happens. Teachers need to be ready to intervene when they observe confusion or uncertainty (Kuhlthau & Maniotes, 2010).

There are six stages of learning in guided inquiry to help provide guidance and modeling. The first stage is initiating, where students start and open the inquiry (Kuhlthau & Maniotes, 2010). Next is selecting, which is when students select their general topic. Then there is the exploring stage. In this stage students explore ideas and background information. Next is formulating, when students begin to form a focus. Then there is the collecting stage. Students synthesize information during this stage. Lastly, students participate in the presenting stage. In this stage, students share and organize their ideas with others (Kuhlthau & Maniotes, 2010).

Marshall et. al (2009) found through their data that elementary teachers wanted to use inquiry-based teaching more in their classrooms than middle and high school teachers.

Integrating into an Elementary Math Classroom

Vygotsky, who is a constructivist learning theorist, suggested that students go beyond just memorizing facts and procedures (Marshall et al., 2009). He finds it important for students to have opportunities to think deeper about the skill practiced, which will in return allow students to think critically and improve their problem-solving

skills (Marshall et al., 2009). When using inquiry-based learning in mathematics, it is important to be grounded in a fundamental aspect of mathematics. This may include problem-solving skills. The purpose of this is because these types of tasks are designed to assist the mathematical activity of students (Dickson et al., 2017).

Bransford et al. (as cited in Marshall et al., 2009) stated that inquiry instruction can improve student's mathematics. Many students view math as a performative subject because they see the goal as getting right answers. Students rarely get opportunities to critically think about the content and ask and answer deep questions (Boaler & Dweck, 2015).

There are many ways that a teacher can incorporate inquiry-based learning into their classrooms. One strategy is to have students work in small groups where they are given specific exercises at the beginning of class. It is important that these exercises are something that students can do with little directions from their teacher. This example is something that could be part of the daily routine in the classroom. They could be something that will help students with their basic skills. It is important that the exercises lead students to different interpretations and solutions (Steurer, 2018).

In inquiry-based learning, there are pedagogical models to help support. The first model is a high-level and open-ended task. Within this model, there are many possible types and levels of math. The next model is the role the teacher plays. Teachers are to guide students through the task by building on prior knowledge. Within this model, students also need to be able to acknowledge the deeper mathematics they are learning. The last model is students sharing their thinking and products with peers and teachers (Dickson et al., 2017).

There is a 4D-cycle of planning model for inquiry-based learning. The pillars of this model are discovering, devise, develop, defend, and diverge (Kogan et al., 2014). In the discovery phase, the teacher introduces an essential question or problem. Students then use their prior knowledge to construct their initial understandings. The next phase is devising. In this phase students learn about the requirements of the inquiry and come up with a plan. Next is the development phase, where students begin to implement their plan. They use math to create the preliminary findings related to the inquiry. Then, it is the defend phase. In the defense process, students present and explain their findings. Students should also reflect on how they got to their solutions and what they may do differently. The last part of the 4-D planning model is the diverge phase. This would be used if the teacher or students wanted to do an extension of the inquiry (Kogan et al., 2014).

A potential example of this would be students designing a room. In the discovery phase, students would be introduced to the concept of creating bedrooms. Next in the devise phase, students would learn about the criteria for their project. An example of the criteria would be the cost of specific materials for the chosen room. Then in the development phase, students would use their knowledge of perimeter and area to help them fit the criteria. In the last stage, the students would present their rooms to the class.

Challenges for Teacher and Students

A challenge that comes with inquiry-based learning is finding the balance between too much and too little structure. When students are in a learning environment that is too open-ended, students can be overwhelmed. Therefore, their learning was unfocused. On the other side of things, an inquiry environment that is too structured can

be harmful to students as well. When this happens the learning environment creates traditional behaviors. Therefore, students have lost the opportunity for deeper levels of thinking (Kogan et al., 2014). While inquiry-based learning is an open-ended approach, it still needs to have structure. If there is little structure then there may be chaos (Dickson et al., 2017).

Inquiry-based learning involves students taking risks. This can be uncomfortable for students. Due to this, it is important for teachers to continually remind students that making mistakes is a part of the learning process (Kogan et al., 2014). Students with a growth mindset are more comfortable making mistakes and taking risks in their learning process. These students also have a love of learning (Auten, 2013). As educators, we all want our students to love to learn.

Inquiry-based learning can either benefit or harm a student's motivation. Students who disliked math were immediately motivated by the openness of inquiry. However, students who did well in a traditional math classroom were more resistant to the inquiry learning environment (Kogan et al., 2014). This would be important to address in math classrooms.

There are some challenges for teachers and students. Large classes can make it difficult for teachers to effectively monitor student behaviors during inquiry-based lessons. Another challenge is for teachers to have access to necessary materials for these types of lessons. Some teachers find that inquiry-based learning is engaging and hands-on, however students have a hard time comprehending the content (Yan et al., 2018). Teachers tend to avoid using inquiry-based learning in their classrooms for many

reasons. Inquiry instruction is more complex than typical teaching strategies. It can be challenging to engage students throughout the inquiry process (Marshall et al., 2009).

Some teachers may not feel motivated to try an unfamiliar strategy. Most teachers do not have exposure to this type of teaching, so some may feel unsure of trying it in the classroom (Marshall et al., 2009). Educators feel overwhelmed by the amount of planning that goes into inquiry-based learning (Goodnough & Cashion, 2006). It can be challenging to cover all the necessary content while teaching math using inquiry-based learning (Marshall et al., 2009). Inquiry-based learning requires teachers to develop the curriculum to fit this type of learning. Teachers feel the pressure to teach all content standards. Due to this, many are unsure about attempting inquiry-based learning in their classrooms (Goos, 2004).

Teachers will also need to take time to reflect on their own beliefs on the role a teacher plays in the classroom setting (Goodnough & Cashion, 2006). It can be difficult to find rich curriculum materials that will work well with inquiry-based teaching (Towers, 2012). Schools need to help teachers become more knowledgeable on how to integrate inquiry-based learning with content (Marshall et al., 2009).

Teacher interventions might help increase self-efficacy of teachers and help them improve their teaching strategies (Marshall et al., 2009). Bandura (as cited in Marshall et al., 2009) defined self-efficacy as “one’s confidence in performing a special task correctly” (p. 4). Self-efficacy of a teacher will impact their willingness to do inquiry-based learning. Teachers will have more self-efficacy, will be more confident, and will be more open to trying new teaching strategies. A teacher’s self-efficacy also

helps teachers overcome potential challenges with inquiry-based learning (Marshall et al., 2009).

The Role of the Teacher

The teacher is the facilitator. In inquiry-based learning, the role of the teacher is to offer help in reaction to students' ideas. The teacher is to solely focus on the students' ideas through this type of teaching (Steurer, 2018). There needs to be a shift in the belief that teachers just pass on knowledge to students (Kogan et al., 2014). Teachers need to participate in discussions on the foundations of mathematics and why students need to learn them (Marshall et al., 2009).

In order for inquiry-based learning to be the most effective, there needs to be appropriate guidance from the teacher (Dickson et al., 2017). The teacher should have explicit expectations throughout the inquiry process (Goos, 2004). One of those expectations is for students to explain their mathematics process and ideas as well as give feedback to peers on their results (Goos, 2004). In inquiry-based teaching, the teacher should use students' interests as best as they can to determine the activities for the given unit. Teachers should also do their best to connect the mathematical task to other subject areas the class is learning about (Towers, 2012).

The structure of the classroom is an important aspect to teaching. In an inquiry-based classroom, the teacher needs to have a predictable structure. Through this structure, the teacher is to scaffold students' thinking by having explicit expectations and structures. The expectations must be accessible for students. The teacher needs to model the process of inquiry to students. To model effectively, the teacher needs to show students how to explain their own thinking (Goos, 2004).

There are specific things the teacher should be doing throughout the inquiry process. While students are working, the teacher is to circulate around the classroom to make comments or ask questions to students. Instead of telling students how to do a task, the teacher is to let the students' work guide the discussion with them (Steurer, 2018). The role of prior knowledge in inquiry-based learning requires teachers to find the balance between telling students what to do and facilitating their thinking (Dickson et al., 2017).

Students may get stuck or feel frustrated throughout the inquiry process. Teachers need to be mindful of how they help their students get unstuck through the inquiry-learning process. Our instinct is to help them fix the situation. In order to keep students motivated, we use our own experiences to help them with a potential solution (Steurer, 2018). Teachers need to resist telling students how to proceed with a task. Instead, scaffold the student thinking to keep the momentum of the inquiry. When a student asks, "Is this right?" it is important to respond with "why" questions (Kogan et al., 2014). Teachers need to encourage frustrated students to take time to reflect, and guide students to make sense of the new information. It is important for teachers to provide targeted interventions throughout the students' learning experiences. (Kuhlthau & Maniotes, 2010). The teacher should show students a genuine interest in their ideas and explanations throughout the inquiry process (Towers, 2012).

There will be a class-discussion about the inquiry. It is important for the teacher to interrupt the class-discussion in order to allow students to take ownership for creating their mathematical ideas (Goos, 2004). During the whole group discussion, it is important for the teacher to finish the lesson by making sure students understood the content. The

teacher does this by clarifying content and summarizing any of the main ideas (Steurer, 2018).

The Use of Questioning

Students always want to be told the answer. It is up to the teacher to think about the questions they are asking their students. Most of the time, teachers ask a question that has a predictable outcome. Sometimes students just want to be told an answer. We need to adjust our questioning to move away from students just asking the teacher a question to get an answer (Goodnough & Cashion, 2006).

Students learn new ideas by asking questions and finding the solutions. Throughout the process, they receive feedback from both the teacher and peers (Steurer, 2018). Problem-based learning allows students to work on many skills. They are able to improve their problem-solving skills as well as more exposure to their curiosity and collaborative skills (Goodnough & Cashion, 2006).

Through the inquiry process, the questions are either from the teacher, peers, or the individual (Harlen, 2013). Students are to ask questions that are of interest to them through the inquiry process. These questions are driven by their curiosity to understand (Harlen, 2013).

When students get stuck, encourage them to talk about what they already did and ask them what they could try next (Dweck, 2015). This helps push their thinking and instills a growth mindset mentality. It is important for the teacher to ask questions that make students clarify their ideas and that allow the teacher to monitor their thinking. When students get stuck, help them remember the endpoint of the inquiry. Through this, the teacher is the model of problem solving (Goos, 2004).

Further Students' Understanding of Mathematics

The intention of inquiry-based learning in mathematics is for kids to experience how mathematics works (Dickson et al., 2017). Many students see math as procedures and calculations, while mathematicians see math as the study of patterns (Boaler & Dweck, 2015). Educators are concerned about students being able to apply their mathematical knowledge to real-world problems. Our students are able to learn math for over 11 years but are not able to apply that knowledge outside of school very well (Boaler, 1998). In 2012, the United States ranked 36th out of 65 countries in math performance (Castiglione, 2019). A reason for this ranking is students are not able to perform higher-level tasks like problem solving. This is due to what students are taught in United States math classrooms (Castiglione, 2019).

Students become more engaged in math and perform better when they are given opportunities to ask questions about a particular math situation or come up with the math problem. Many students are not given these types of experiences. Instead, they are just learning procedures and answering questions that do not have as much meaning (Boaler & Dweck, 2015). Student engagement in the learning process is crucial to students' success in the math classroom. Inquiry-based learning allows the students to be active participants in their learning, which will help improve their academic success (Zafra-Gómez et al., 2014). Through this active learning process, students are able to enhance their critical thinking skills and have a more positive attitude towards mathematics (Wiggins et al., 2017).

Zafra-Gomez et al. (2014) discovered in their research that inquiry-based learning helped improve students' understanding of content. Students are given opportunities to

elaborate on their thinking and ideas through inquiry-based learning. This will help students better understand the content (Wiggins et al., 2017).

The inquiry-based learning section helped set the foundation for this paper. It is first important to understand these frameworks to better understand this type of learning. The next section will go into another important aspect of inquiry-based learning, which is teamwork for both teachers and students. Collaboration between teachers and students is necessary to address and understand.

Teamwork (Teacher and Student) in Inquiry-Based Learning

Collaborative work for students is a big part of inquiry-based learning. It is important for students to work together because collaborative learning increases their learning as well as their peers' learning (Yew et al., 2011). Students and teachers play important roles in this collaboration; therefore, it is important to address the roles they each play. How involved should the teacher be? What is a teacher's job during this teamwork in inquiry-based learning? It is also important to address what challenges students may face during collaborative work. Some students thrive working with others, while some may have a challenging time doing this. There are many benefits to students working in teams as well. It is important to point out the benefits students receive from working with others in inquiry-based learning.

Role of the Teacher

The teacher should be seen as the facilitator of learning while students are engaged in collaborative work. As a facilitator, the teacher does more listening and asking questions. Most teachers are used to lecturing during instruction (Goodnough & Cashion, 2006).

Implementing inquiry-based learning can be complex, which is why it takes a team to teach and assess. This team approach allows schools to fully use the expertise of their teachers. The recommendation is to have a three-member team to help plan and supervise the inquiry (Kuhlthau & Maniotes, 2010). It is important for teachers to critically think about their practices and teaching beliefs (Goodnough & Cashion, 2006).

In order to get students to be active participants, the teacher must appropriately choose the learning activities as well as the interactions with peers (Goos, 2004). For teamwork to be successful, teachers need to be mindful of how they form the groups. The teacher needs to have explicit expectations for cooperation between students. Teachers should be thinking about the size of groups and the role of each member in the group (Yew et al., 2011) .

Members of the group must interact with one another to help each other accomplish the task. This is an expectation that the teacher explains to their students. The teacher should establish a positive interdependence for each group. What this means is that each collaborative group understands that they are relying on each other to accomplish the goal of the group (Yew et al., 2011) .

The teacher should create a teamwork objective to go along with the academic objective. There should be a specific goal for students to work on mastering throughout

the lesson. While students are working, the teacher should monitor groups by asking students to explain their thinking (Yew et al., 2011).

Throughout the collaborative learning process, there are certain ways the teacher needs to support their students. In order for students to be successful working in a group, they must be introduced to some important skills. These skills include decision making, trust, leadership, and communication. It is also important for teachers to make sure to give students adequate time to reflect and process their work and goals. Within that reflection, students also need time to process how their group is doing while working in their collaborative team (Yew et al., 2011).

Challenges for Students

Many students may not be used to working on problem-based learning in a collaborative group, therefore it may take them time to get used to working as a team (Goodnough & Cashion, 2006). Some students may lack teamwork skills necessary to work in a successful group (Yew et al., 2011). Students need time to learn how to effectively work in a team. Students should set up norms for when working with their group. This will help students work well with each other. They also need time to get used to working as a team with these norms. Teachers should give students a few weeks of just focusing on working together and not necessarily the content (Boaler & Dweck, 2015).

Another challenge for collaborative work is accountability. While students are working in a collaborative group, they must be accountable both individually and for the group. Students in the group must be clear about their role in the group and hold each other accountable to that (Yew et al., 2011).

Benefits for Students

Inquiry-based learning group work gives students the opportunity to learn how to effectively work with others. In these groups, students learn how to better share ideas and make decisions within a group (Goodnough & Cashion, 2006). Students learn new ideas from their peers. While working together, students explain their ideas which helps them better understand the content. Students also get feedback from their peers through this process (Steurer, 2018).

According to Lucas, Gunawardena, & Moeriea (as cited in Tawfik et al., 2018) collaborative learning allows learners to share ideas, interact with others who may have different ideas, and debate new knowledge as they find solutions to the inquiry. Students usually feel more comfortable sharing their ideas with a small group rather than the whole class (Goodnough & Cashion, 2006). There are many benefits to students communicating with their peers. They can learn a lot from working with each other. Working in a collaborative team allows students to work on their communication skills (Goos, 2004). When students receive validation from their peers, it may make them feel good about themselves for coming up with an idea (Steurer, 2018). When a student gets stuck, they can get help from their peers (Steurer, 2018). Students gain a deeper understanding of the material by explaining their thinking to their peers in a collaborative group through inquiry-based learning (Goos, 2004).

Students discovered that while explaining their ideas to their peers, they themselves sometimes discovered a mistake they had made (Goos, 2004). Working together allows students to help one another when they get stuck. Students are given opportunities to work through the challenges before going to the teacher (Goos, 2004).

Students are able to take more accountability for their learning (Goodnough & Cashion, 2006). Students are able to take ownership of their learning, while their peers contribute ideas to help better understand the mathematical task (Goos, 2004). Students get used to sharing their ideas with peers in inquiry-based learning, that is they will naturally turn to their peers when they need help. Students can work through the task together without having to be told by the teacher (Goos, 2004). Students are more likely to understand the content when they are given opportunities to work through it in a team instead of being told how to do something (Goos, 2004).

Teamwork and collaboration have many advantages as well as challenges for both teachers and students. In my curriculum, students will be completing their tasks in a small group. Overall, collaborative work can have a positive impact on a student's mindset. The next section will introduce math mindsets and how that affects both teachers and students in the learning process.

Math Mindsets

Our mindset towards math is influenced by many things. It is important to recognize what our own mindset is toward mathematics and think about how it became that way. In this section, I explain math mindsets. It is first important to learn about growth versus fixed mindset. What influences a person's mindset on mathematics? In this section, I explain some potential influences on a person's mindset towards math. Within those influences, it is also important to discuss the role a teacher plays in shaping a student's math mindset. How does a teaching strategy impact a student's math mindset? There is a connection to how math is taught and your math mindset. Teachers need to be

aware of their teaching practices, and how they may be influencing their students' mindsets.

Growth Versus Fixed

There are various viewpoints on mindset. Some people believe that intelligence is either fixed or flexible (Castiglione, 2019). Many studies have evidence that students' mindsets impact their academic achievements (Claro & Loeb, 2019). A person's mindset is part of their personality. You can change your mindset by acknowledging growth versus fixed. Once you have been able to identify which one you fit in you can start to make changes to your mindset towards something (Dweck, 2006).

Our past experiences can impact our mindset on something. It is important to reflect on what experiences within an area caused you to have the mindset that you currently have. Carol Dweck tells us to ask ourselves these questions: *What did I (or can I) learn from that experience? How can I use it as a basis for growth?* (Dweck, 2006, p. 53). Students and adults have a more positive outlook on learning when their mindset shifts from fixed to growth (Boaler & Dweck, 2015). Changing students' mindsets has a huge impact on their academic achievements (Dweck, 2015).

Dweck pointed out (as cited in Claro & Loeb, 2019) that people who have a fixed mindset put in less effort and may steer away from challenges. They are also more likely to quit than a student with a growth mindset. Therefore, this fixed mindset may limit their development. Students with a fixed mindset worry more about what their peers may think about their abilities. This creates a competition between a student and their peers to prove they can complete the task. When this student encounters challenges, they are then more

likely to give up because they do not have the necessary strategies to help themselves (Lee, 2009).

Students with a fixed mindset typically focus on the performance by a grade, instead of the learning they acquired (Auten, 2013). When a student with a fixed mindset does bad on a test, they will typically think it was due to their ability to do the task. A student with a growth mindset will reflect and tell themselves that they will do better next time (Lee, 2009).

While working through a mathematical task, most people have to work through the struggle. There is this belief that some are math people and it comes easy to them; however, most people do encounter challenges and have to work through them (Lee, 2009). Students with a growth mindset are more prepared for the challenges they may encounter. This type of student may also enjoy the struggle of figuring out the problem. A student with a fixed mindset might see this struggle as they are bad at math and cannot do it (Lee, 2009).

A fixed mindset enables students to give up easier when a task gets challenging for them. Students with a growth mindset persevere when the task gets hard (Boaler & Dweck, 2015). According to a study done by Dweck, 40 percent of students held a fixed mindset. The percentage of students with a growth mindset was also 40 percent. The rest of students surveyed were between fixed and growth mindset (Boaler & Dweck, 2015).

A student with a growth mindset firmly believes that their effort will help lead them to success (Lee, 2009). Growth mindset students want to be given challenging tasks because they see them as opportunities to learn and grow. Overcoming challenges in the learning process brings this type of student great joy (Lee, 2009).

Background

Motivation and mindset are closely linked in terms of a student's success in math. As cited in Dweck's research, when students see their intellectual ability as a "gift" or mindset, there is less motivation towards their schoolwork (Castiglione, 2019). These students also struggle more when they are faced with a challenge, where they then question their ability (Castiglione, 2019). Students' negative feelings towards math is a contributing factor to the years of underperformance of math. (Castiglione, 2019). There continues to be a conflict on students' achievement in mathematics. The Program for International Student Assessment found in 2012 that the United States ranked 36th of the 65 participating countries in math performance. In the United States there is a disconnect between what is taught and students being able to perform higher level tasks such as problem solving (Castiglione, 2019) This conflict is important to address because there are many important careers that involve mathematics. We need to get students ready for those kinds of jobs (Bostwick et al., 2020).

According to Boaler (as cited in Castiglione, 2019), math is a source of anxiety and fear while students in America hate math. Everyone has beliefs towards how they learn (Boaler & Dweck, 2015). Our mindsets are an important factor in our success in school because it helps determine our learning behaviors. Our mindset and learning behaviors can sway our learning outcomes (Boaler & Dweck, 2015). According to Good et al. (as cited in Bostwick et al., 2020), when a student's math mindset is growth, they will be more confident towards their math abilities.

Dweck and Boaler see math as a subject that needs to rethink the mindset of both students and teachers (Boaler & Dweck, 2015). In the United States and British societies,

there is a held belief that only some people are good at math. Many people hold this belief about math, but not in other subject areas. Part of the change needs to be to not have the math mindset of right and wrong answers. Instead our math mindset needs to understand the creativity and interpretation that are involved in mathematics (Boaler & Dweck, 2015).

It is important to teach students about mindsets within mathematics because so many students carry a growth mindset in other areas of their life but continue to think they are bad at math. In order to overcome that, teachers need to discuss mindset within mathematics (Boaler & Dweck, 2015). It is important to set positive norms for math class at the beginning of the school year (Boaler & Dweck, 2015).

“The very best opportunities to learn come about when students believe in themselves” (Boaler & Dweck, 2015, P. 5)

Influences on Math Mindset

Teachers and parents play a vital role in shaping a child’s math mindset. Boaler suggested that if teachers and parents help change how students view math, it will lead to success in mathematics (Boaler & Dweck, 2015). A child’s mindset or negative feelings about math often stems from parents. This often results in negative self-talk about their math abilities (Castiglione, 2019). Self-talk influences a student’s math mindset. There needs to be a shift from thinking “I am not good at math.” Instead, the self-talk should be, “I can get better.” Along with this change in negative self-talk, it is important to address the need to be okay with making mistakes. When the self-talk changes, students will be more willing to try things again and learn from their mistakes. These changes will lead to more improved math self-efficacy (Castiglione, 2019).

Many teachers and parents praise students when they do something well in mathematics. This praise has a negative effect on students when it is fixed praise. Fixed praise is when a child is told they did something well or that they are smart. If this fixed praise occurs, a student will feel good when they do well, but will have challenges when they might have a harder time with a task. This may lead the child to not feeling smart. The way we praise kids can alter their math mindset (Boaler & Dweck, 2015). The praise of “you are smart” has very detrimental effects on a student’s math mindset. Telling a student “you are smart” will create problems for them when they make mistakes or when they fail at task (Boaler & Dweck, 2015). The words teachers choose to use with students have an impact on students’ mindset. It is important to use language that mentions a student’s effort (Lee, 2009). Teachers and parents need to think about what they say to students and how it may impact their math mindset. Our words can be powerful.

The teacher needs to give students appropriate time for struggle and engagement in the material. Along with that, the teacher needs to find ways for students to have a deeper understanding of mathematics (Lee, 2009). Mistakes and students’ level of comfort with them can influence their math mindset. Many students have the belief that if they often make mistakes in math, that they are not good at it. This narrative needs to change (Boaler & Dweck, 2015).

Teacher Involvement in Math Mindset

According to Mascaret and Patrick (as cited in Bostwick et al., 2020) there is a connection between a teacher and student math mindset. Due to this, it may be important to examine a teacher’s math mindset and how that impacts their student’s success in math (Bostwick et al., 2020). Rattan and Rissanen pointed out (as cited in Bostwick et al.,

2020) that teachers with a fixed mindset can lead to more low achievement of students. A change in the teacher's mindset is the first step to changing the student mindset (Castiglione, 2019).

Educators bring their learning history into the classroom with them. Many teachers had negative experiences with math and unfortunately carry those with them while they teach math (Boaler & Dweck, 2015). A teacher's anxiety towards teaching math may impact their student's math mindset. Students observe this anxiety through instructional practices. This math anxiety of the teacher may make students perceive the teacher's math mindset as fixed (Ramirez et al., 2018).

Teachers need interventions on how to shift their math mindsets which, in return, will help transform students' math mindsets. These interventions could be very beneficial for students' long-term success in school (Boaler & Dweck, 2015). Teachers may need to challenge their own beliefs about how we teach and learn math. Something that teachers need to learn and address is how to respond to a student who gives up easily or has continual negative math self-talk (Castiglione, 2019).

Teachers need to start to address the whole student, which includes the student's mindset. This needs to be the new normal. It is up to the teacher to give students opportunities to create positive outlooks as well as deeper mathematical thinking (Castiglione, 2019).

There is a connection between teacher motivation and the outcomes of their students. Within this connection, it is important to examine a teacher's growth constructs and how that contributes to a student's success (Bostwick et al., 2020). Teachers with a growth mindset saw more success with growth mindset interventions with students.

Teachers with a fixed mindset did not observe student's growth mindset. A teacher's mindset directly impacts the students' math mindset (Bostwick et al., 2020). From day one, students need to understand that their teacher believes in them. This will help set students up for success (Boaler & Dweck, 2015). Teachers need to effectively communicate positive expectations to motivated and struggling students (Boaler & Dweck, 2015). Teachers need to encourage students to be mathematicians. Boaler defines mathematicians as people who, "see their subject as creative, beautiful, and aesthetic" (Boaler & Dweck, 2015, p. 181).

The Impact of Teaching Strategies on Math Mindset

Brain research shows us that with the right messages and teaching strategies, we will see an increase in students' achievement in mathematics (Boaler & Dweck, 2015). Bad math teaching can lead to students having a negative mindset towards mathematics (Boaler & Dweck, 2015).

A lot of teachers may experience anxiety while teaching math due to their educational history. If students perceive their teacher as anxious to teach math, that may impact students' math mindsets. Students can pick up on if their teacher has a fixed or growth mindset based on how their teacher teaches them math. An anxious teacher might unintentionally be modeling to the students that not everyone is good at math (Ramirez et al., 2018).

Math is often seen as a procedure and getting to a right or wrong answer. If we teach math this way, it is seen as performative instead of understanding patterns and the math behind the problem (Lee, 2009). Karp (as cited in Ramirez et al., 2018) found that elementary teachers with a negative math mindset used more algorithmic teaching. These

teachers used this strategy more instead of more student-centered activities that help students gain a deeper understanding of math content.

We need to teach math as an open, growth, and learning subject. Most math problems are posed and students perform a procedure to find an answer. This makes it challenging for students to have a growth math mindset. Teachers need to use less questions like that and instead give students opportunities to explore mathematics. When the task is more open, students will be engaged and get more out of it (Boaler & Dweck, 2015).

Inquiry-based learning often has students working in groups. If students have a growth mindset towards math, it will help them work collaboratively with students. This mentality towards math creates an environment where students will work well together, instead of a competitive environment. Students' math mindset and the teaching strategy will help with students' success in mathematics (Bostwick et al., 2020). Open math tasks allow the student to be the inquirer. The student is not just finding an answer but is able to critically think about the mathematics content. This helps students take ownership in their learning, which will help foster a growth math mindset (Boaler & Dweck, 2015).

Outcomes for Students with a Growth Math Mindset

According to researchers, a student's academic success is rooted in their growth goals and their growth mindset (Bostwick et al., 2020). Students with a higher academic performance are more likely to have a growth mindset (Claro & Loeb, 2019). Students with a growth mindset will have an easier time when they are challenged with real-world problem-solving demands in math (Castiglione, 2019).

Studies have shown that students' mindset impacts their academic achievements. The results of these studies are that mindset interventions can help a student's academic performance. This is especially true of lower performing students (Claro & Loeb, 2019). Research shows that students with a growth mindset are more motivated and put in more effort to their work. Due to this, these students typically have more academic success (Auten, 2013). Bostwick et al. found that students who had a growth mindset did better in their math class. Students' math mindset was not the only contributor to student success, the classroom environment also played a part. In this study, the classroom environment centered around collaboration instead of competition. This helped with the student's growth mindset and success in their math classrooms (Bostwick et al., 2020).

Blackwell et al. (as cited in Boaler & Dweck, 2015) conducted a study of some middle school students. In this study, this tracked students throughout two years. At the beginning of the study, students completed a survey that asked them about their mindset. The results were very telling in the connection of mindset to success in mathematics. The students who had a fixed mindset achievement stayed constant. On the other hand, the students with a growth mindset showed major growth in their mathematics (Boaler & Dweck, 2015). Students who see their intelligence as growth do better in school than students who see their intelligence as fixed (Dweck, 2015).

There are many impacts on how an individual's math mindset is formed. Teachers and parents can play a vital role in a child's opinion towards math. It is important to understand how our mindsets are formed and how they affect us in school. We all must address growth versus fixed mindsets and how our mindsets impact us and our learning. The next section will discuss the advantages to inquiry-based learning for students. I will

make a connection between how inquiry-based learning and classrooms can foster a growth mindset about math in students.

Advantages to Inquiry-Based Math Classrooms

This section discusses the advantages of embedding inquiry-based learning into elementary math lessons. Within these advantages, it is important to address the success and challenges students may face within this type of learning. Some students will feel uncomfortable with inquiry-based learning and some may thrive in it. It is important to address the classroom environment in an inquiry-based learning classroom and the impacts that has on student academic success as well as their math mindset. There is a connection between how students are taught and their mindset towards the subject. The last part of this section will discuss how the inquiry-based learning model can help foster a positive math mindset in students.

Student Success

Inquiry-based learning allows for flexibility in the learning environment because students are able to learn in a way that is best for their personal learning style (Kogan et al., 2014). Learning math through inquiry-based instruction allows students to learn through their personal interest (Harlen, 2013). Students have higher amounts of learning when they are given opportunities to engage in active forms of learning, which are authentic (Tawfik et al., 2018). Through guided inquiry learning, students are able learn to acknowledge their feelings and thoughts. Within that process, students can understand how they learn, and transfer that to future learning (Kuhlthau & Maniotes, 2010). Inquiry-based learning allows students to apply their mathematical knowledge in other parts of their life. In this learning process, students are able to think deeper about the

information through synthesizing, analyzing, and evaluating their knowledge (Richmond et al., 2015).

Inquiry-based learning allows students to create skills in reasoning, which will help them in their lives and careers (Harlen, 2013). This type of learning allows students to better understand the world around them through curiosity. This curiosity and understanding of society will hopefully help them with decisions and future careers (Harlen, 2013).

It is important for mathematics to connect to real world scenarios. Inquiry-based learning relates the real-world to mathematics. Students can apply this connection to their decision making and understand potential consequences (Harlen, 2013). Another advantage is it helps students prepare for jobs related to technology and engineering. These careers are very important to our changing society. Our world is reliant on these kinds of professions (Harlen, 2013).

Collaboration can be beneficial to a student's success. Inquiry-based learning allows students to collaborate. Through this collaboration, students are able to help each other as well as give each other input. This process allows students to not only improve their understanding but helps shape their math mindset. These strategies help foster a growth mindset for students (Dweck, 2015). Inquiry-based learning can help students better understand the mathematics they learn, which will allow them to use these skills in more practical ways in their everyday lives (Harlen, 2013).

Inquiry-based learning allows students to grow in areas that they would not in a traditional math classroom. Goodnough and Cashion (2006) discovered in their research three areas that students were able to grow in from doing inquiry-based learning. Students

improved working and making decisions in a group setting. The students also mentioned getting better at research and presenting information to their class (Goodnough & Cashion, 2006). Inquiry-based learning is believed to help prepare students for future learning and potential careers. This type of learning allows students to get experience with coming up with ideas and following through on a plan. Students can get experience with innovation through this kind of learning process (Acar & Tuncdogan, 2019). Students who have experienced inquiry-based learning in their classroom favored this type of learning because they were an active participant in their learning. The students were more engaged with the learning because of this ownership (Goodnough & Cashion, 2006).

Classroom Environment

Inquiry-based learning creates an environment that is student-centered. Many teachers have to change their teaching approaches to meet this (Goodnough & Cashion, 2006). Teachers need to create an environment that allows students to know it is okay to make mistakes and allow time for students to reflect on their mistakes (Steurer, 2018).

Inquiry-based learning classrooms are proven to do a better job of creating a supportive classroom atmosphere, where students are provided with continual feedback on their work (Kogan et al., 2014). Inquiry-based learning gives students many opportunities for various forms of learning which include: curriculum content, information literacy, learning how to learn, literacy competence, and social skills (Kuhlthau & Maniotes, 2010). Inquiry-based learning is believed to prepare students for all types of situations. Those situations include traditional classrooms, which students will have in secondary (Kogan et al., 2014).

According to Cox and Walton et al. (as cited in Auten, 2013), students' interactions with peers and teachers in the classroom environment have an impact on each student's mindset. The environment of the classroom can determine a student's sense of belonging and confidence in the content. This shows that the classroom environment can influence a student's mindset. The classroom environment helps mold students' mindsets towards their academic outcomes (Auten, 2013). Teachers play an important role in creating a classroom environment that sets students up for success. It is important to create an environment where students want to learn and are willing to work hard. Within that environment, teachers need to provide necessary tools for students to use when they encounter difficult work (Auten, 2013).

It is important to have explicit modeling of inquiry at the beginning of the year. This helps set the stage of the process of mathematical inquiry from the start (Goos, 2004). In an inquiry-based learning environment, teachers need to be sure to build a trusting environment. Within this trusting environment, students will become more comfortable making mistakes and reflecting on them (Steurer, 2018).

Inquiry-based Learning Influence on Math Mindset

Research shows that students who participated in inquiry-based learning had a more positive attitude toward mathematics. There was a study on the effectiveness of inquiry-based learning at four universities. In this study, students completed a survey about their math beliefs and attitudes. The students who participated in the inquiry-based learning courses, showed more growth in their math mindset and confidence in their math abilities. Within that study, these students also had a better understanding of the content (Steurer, 2018). These students felt more confident in their math abilities (Steurer, 2018).

If inquiry enabled learning based on the needs of each student, then teachers are not the final or only warrantors of truth in the math classroom (Kogan et al., 2014).

A student's ability to learn from their mistakes is rooted in their growth mindset (Steurer, 2018). An important part of inquiry-based learning is that making mistakes is part of the learning process. This type of learning allows students to learn how to get unstuck (Steurer, 2018). In this instance, there is a connection between growth mindset and inquiry-based learning.

Students who are more involved in the learning process have an easier time fostering a growth mindset (Dweck, 2015). Teaching strategies can have an impact on students' mindset towards math. Wiggins et al. (2017) found success in their students' mindsets after completing their inquiry enrichment study. After the study they interviewed students. Students stated that they were now more confident in their mathematical ability. Another student mentioned that they now feel braver when it comes time to dealing with the challenges in math problems (Wiggins et al., 2017). Inquiry-based learning had a very positive influence on students' math mindset. 78 percent of students who participated in the project had a new perspective of math (Wiggins et al., 2017).

Curiosity and inquiry-based learning have a strong relationship. Students with a growth mindset are proven to be more curious about their learning. They are also accepting that work will sometimes get hard (Auten, 2013). Growth mindset and inquiry-based learning have a direct correlation in the success of students.

Teachers should make sure that students' needs are the priority. The strategies and content should address the needs of the students' learning. This will help student

academic success (Auten, 2013). Inquiry-based learning allows teachers to ensure that their classroom is student centered. When students are given opportunities to take ownership of their learning, they are able to be more engaged in critical academic thinking. Active engagement and mindset impact a student's ownership in their learning. Their attitudes affect how they take ownership in their learning (Auten, 2013).

There are many advantages to conducting inquiry-based learning in mathematics. This type of learning can make an impact on students' attitudes towards the subject. Many teachers and students are anxious about their mathematics abilities. If we change the way math is taught, it could be huge for both teachers and students.

Summary

To explore the question: *How can inquiry-based learning in Elementary mathematics help create a growth mindset in students*, this chapter focused on literature about the following themes: inquiry-based learning, teamwork (teacher and student) in inquiry-based learning, math mindsets, and advantages to inquiry-based math lessons.

Many teachers and students have experienced a negative relationship with mathematics, which in return can lead to a negative math mindset. I believe a significant cause of that is the way many of us are taught math. For many, math is taught as procedures and memorization. According to Boaler and Dweck, math should be taught as a subject of patterns and connections (Boaler & Dweck, 2015). Inquiry-based learning can be an approach educators can take to change how we teach mathematics. Within this type of learning students are taking more ownership for their learning, which will hopefully have an impact on their math mindset.

The literature review explained some of the successes and challenges for both teachers and students with inquiry-based learning. I think that as both teachers and students get more comfortable with this type of learning the success will outweigh the challenges. The research in the literature review proves the urgency to change the way math is taught.

As a third-grade teacher reading the literature, I continued to reflect on my practices and what changes I can make in my classroom. I connected with many of the challenges teachers mentioned about inquiry-based learning. However, I think that if teachers are properly trained and have a support team for inquiry-based learning, we can have a huge impact on student's math mindsets.

Chapter Three will be an overview description of my project. In this chapter, I will discuss the methods and frameworks. Along with the framework, I will explain the design. This will help readers better understand how I created my curriculum. Another important part of Chapter three, will be the rationale for my project. I will explain the significance and who I am creating this project for. Finally, I will explain how my curriculum answers my research question: *How can inquiry-based learning in Elementary mathematics help create a growth mindset in students?*

CHAPTER THREE

PROJECT DESCRIPTION

Introduction

Chapter two reviewed the literature on inquiry-based learning and math mindsets. The themes explained were inquiry-based learning, teamwork (teacher and student) in inquiry-based learning, math mindsets, and advantages to inquiry-based math lessons. Chapter three describes my capstone project and outlines the main components. This project will address my research question: *How can inquiry-based learning in Elementary mathematics help create a growth mindset in students?* Inquiry-based learning and math mindset are two important areas of research due to the many individuals who think they are not math people. According to Good et al., (as cited in Bostwick et al., 2020) when a student's math mindset is growth, they will be more confident towards their math abilities. There continues to be a conflict on students' achievement in mathematics. This conflict is important to address because there are many important careers that involve mathematics. We need to get students ready for those kinds of jobs (Bostwick et al., 2020)

First, I describe my project. Within that section, I explain assessment, design, implementation, and evaluation. The next section is the rationale for my project. Within that section, I describe some of the research to back up why I am completing this curriculum. Then, I explain the setting in which I am creating this curriculum for. Next, I will describe the participants at my school who will be utilizing the curriculum. In that section, I will have explicit statistics on the students and teachers. Lastly, I will explain the timeline for my project.

Project Description

My project will be a curriculum for third grade math classes. The curriculum has activities and lessons teachers can use that introduce students to inquiry-based learning and math mindsets. Students will complete the activities in a team. This gives students opportunities to build community. The students work in their teams every day. There are a total of 16 lessons in the curriculum. Each lesson should take about an hour. The focus of this unit is multiplication. It is an introductory unit to multiplication. It focuses on two Minnesota state standards. The two standards are:

3.1.2.3 Represent multiplication facts using a variety of approaches, such as repeated addition, equal-sized groups, arrays, area models, equal jumps on a number line and skip counting (Purslow, 2016).

3.1.2.4 Solve real-world and mathematical problems involving multiplication and division, including both "how many in each group" and "how many groups" division problems (Purslow, 2016).

Another component of the curriculum is students reflecting on their mathematics process through a math journal. Their math journal is a place for students to reflect on their math mindset. Each lesson has a specific question for students to answer in their math journals. Students should be given at least ten minutes to write in their math journals.

The goal of this curriculum is for students to gain a conceptual understanding of multiplication, while reflecting on their math mindset. Students experienced learning multiplication with an inquiry approach in their group. The inquiries get students to think critically about the process for solving multiplication.

The teacher can then embed inquiry-based learning where it fits into their math curriculum and standards. Math mindset is something that both the teacher and students should continue to reflect on throughout the year. This curriculum gives teachers and students opportunities to assess their math mindset on a continual basis and set personal goals.

Assessment

Before teaching these lessons, teachers should reflect on their own math mindsets. They will take the self-assessment that I have created for my project. Then they should discuss with their teammates or a coach. Teachers should use this reflection to help them teach these lessons. They should also continue to reflect their math mindset and how it impacts their teaching and students. It is very important to use a tool like a self-assessment to continue to evaluate your teaching practices and goals.

Students will take a self-assessment on their math mindset and how they best learn math. Teachers should give students opportunities to discuss with a small group as well as have a whole group discussion. Within that discussion, the teacher should ask specific questions to get the conversation going. A list of questions for this discussion will be listed in the curriculum. The teacher can choose which questions will best fit their students. The student and teacher should continue to self-assess their math mindset and how they are doing in math class.

The self-assessment created for both teachers and students are something that they can each continue to go back to and reflect on. The purpose of starting these assessments at the beginning of the unit is to set the stage for inquiry-based learning and math mindset. These assessments will be a helpful tool for both teachers and students. After the

unit, students and the teacher will take the same assessment. Next they reflect on their math mindset, to see if it has changed since the start of the unit.

Design

I used Understanding by Design (UbD) (Wiggins & McTighe, 2011). In this model of curriculum planning, the teacher plans backwards. There are three stages in backward design; desired results, evidence, and learning plan (Wiggins & McTighe, 2011). According to Wiggins and McTighe (2011), the best way to receive long-term results is to use the backwards design model.

I planned my curriculum backwards by thinking about the goals to help create it. The two goals of this curriculum are: Students have opportunities to reflect on their math mindset and have a deeper understanding of the material. I think that inquiry-based learning with a focus on math mindset helped achieve those goals for students.

This curriculum is specific to third graders. While designing a curriculum it is also important to consider the standards and content. I will plan around what content students are expected to understand. For my curriculum, I will be using two of the important multiplication standards for third grade students.

Implementation

Teachers will implement these lessons at the beginning of a multiplication unit. The goal of these lessons is to establish a foundation for the use of multiplication, evolve math mindset, and build community in the classroom.

The lessons are created for third grade teachers. They best fit for third grade classrooms, however some of the activities may work with other grades with variations. For example, 4th or 5th grade teachers could use the same activities, just with bigger

numbers. The lesson and activities fit within the hour block math time. Teachers can use the lessons in consecutive days or pick and choose where they might fit into their content. If third grade teachers or older elementary teachers think their students need a review of some of the foundational parts of learning multiplication, this could be a resource for them to use.

Evaluation

It is important for teachers to evaluate the evidence of student learning. Teachers evaluate student learning through observations and questioning. This is done either during small group time or during class discussions. The math journal can be used for teachers to evaluate students progress towards the standards as well as their math mindset development.

The worksheets students are completing with their small groups is another form of evaluation for teachers. This helps teachers get a better understanding of how students are doing in the unit. It is very important that the teacher uses the math journal, class discussions, group work, and individual questioning to evaluate student progress.

The assessment, implementation, design, and evaluation are all important components of my curriculum. They need to be very explicit in my curriculum in order for it to be simple for teachers to use. Next, I explained the rationale for my curriculum. I described some of the research that goes into why my research is important to student and teacher success in math classrooms.

Rationale

Jo Boaler and Carol Dweck are two very important researchers in my area of study. They have done a lot of research on mindset as well as math mindset. Boaler has done a lot of research on math mindset and strategies to help teachers teach math in a better way. She has also done research on math mindset and how that is formed. Dweck has done a lot of research on mindset and the impacts it has on our success (Dweck, 2006).

According to Dweck's studies, 40 percent of students held a fixed mindset. The percentage of students with a growth mindset was also 40 percent (Boaler & Dweck, 2015). Students and adults have a more positive outlook on learning when their mindset shifts from fixed to growth (Boaler & Dweck, 2015). Therefore, it is very important for both teachers and students to assess their math mindset. I think it is also important to change how we teach math to help students have a growth mindset in their math classes.

Teachers and parents play vital roles in shaping a child's math mindset. Boaler and Dweck (2015) suggested that if teachers and parents help change how students view math, it will lead to success in mathematics. Dweck and Boaler think that many students have a negative mindset towards mathematics due to how we teach it. They both see value in changing the way educators view and teach math. This will help students long term in their mathematics courses as well as their life.

Boaler and Dweck are two very important researchers in the fields of mathematics and mindset. I found their research to be very important and useful for educators. It is great that they have collaborated with one another. It shows how important this area of

research is. The next section will explain the setting for my curriculum. The setting will describe the students and teachers who will be utilizing it.

Setting

The school district I work at is a charter school in Saint Paul. The school has a large number of English learners. According to the Minnesota Report card, 35 percent of students are English learners (2020). The school I teach at is a Kindergarten through twelfth grade school. There are 2,350 students enrolled. Each grade in elementary has seven homeroom teachers with two English Language learner teachers. 98.3 percent of students are asian. 0.5 percent of students are Hispanic. And 0.3 percent of students are Black or African American. Many students receive free and reduced lunch. 75 percent of students qualify for free-reduced lunch (2020).

The intended setting for my curriculum implementation is an elementary math classroom. I currently teach third grade, so I created lessons for those students. I did my best to try to reach each grade or provide variations within each lesson. That way more teachers can use these lessons.

The teachers who will be using this curriculum have a wide range of experience. Most teachers have been teaching less than ten years. Some have master's degrees. 95.95 percent of teachers are licensed. 21.30 percent of teachers have advanced degrees (2020).

While planning a curriculum, it is important to think about who will be using it. With the teachers and students in mind, they helped me create a usable curriculum. I will explain the participants in the next section. Within that section, I describe who will participate in the curriculum, and who will help create it alongside me.

Participants

The intended audience is my third-grade students. I did my best to create a curriculum that has variations for grade levels across elementary. I want this curriculum to be something that is accessible to teachers across elementary. It could be a resource that teachers pick and choose what will work for them and their students.

My content expert is part of my audience. I used my content experts to guide me to a curriculum that will be accessible for educators to use. Also, they helped me find ways to best meet the needs of students. My content expert helped me find resources to create my curriculum.

The curriculum is created specifically for third grade students with the help of my team. My outside experts on the third grade team helped me create a curriculum that worked for my student population. Lastly, I will describe the timeline for my project. In that section, I will set goals for when this curriculum will be able to be used in the classroom.

Timeline

My goal is to finish the project by winter 2020. I spent a few weeks planning out my lessons for the three week curriculum. The curriculum took about two months to complete. My content expert Linda Manhardt, gave me feedback on my project throughout this process. We met every few weeks to discuss the progress on my project.

I would like this curriculum to be ready to use by the fall of 2021. These lessons are designed for teachers to use at the beginning of their multiplication units. They will help students build relationships with their peers as well as set the stage for how mathematics will be for the year. Students will be able to reflect on their math mindset

and on how they learn mathematics best. The goal would be to apply this kind of reflection and type of learning for the rest of the math units for the year.

Teachers could also use these lessons at any point in the year. It could be used as an engagement or self-reflection tool for students. These multiplication strategies and activities can be used for review or if students need remediation. However, inquiry-based learning and math mindset are something the teacher should continually work on with students.

The curriculum is designed to be used as an introduction to multiplication. However, with the timeline above, it could be something that is used in the spring when complete. For best results, teachers should use this as soon as possible in the school year to introduce multiplication to their third grade students. This could be a curriculum that teachers use when it best fits their student's needs. If students are lacking foundational understanding of multiplication this is a resource teachers could go back to. I think that teachers should work on math mindset activities through inquiry-based learning when they can.

Summary

An outline for my curriculum was provided in this chapter. I described some of the key components of my project. Within the project description, I explained the assessment, design, implementation, and evaluation for my curriculum. The rationale centers around why so many students and adults have a fixed mindset towards mathematics. I also explained the research that explains why educators need to change the way we teach math instruction. An overview of the participants and setting explained more about who will be using the curriculum. Lastly, I included a timeline of my project

and when teachers will be able to use it. In chapter four, I reflect on the process of creating my capstone project.

CHAPTER FOUR

CONCLUSION

Introduction

Math was always a challenging subject for me throughout my education because of the way it was taught to me. Once I had teachers that provided me with experiences that made it more positive for me, I started to see myself as someone who could be successful in mathematics. In college, when I was taking the class Teaching Mathematics, I was able to learn math in a way that allowed me to feel confident about my math abilities. This class made me critically think about the math processes that I was doing, and the students I was working with. I firmly believe that the way we teach math and the mindset of math teachers has a huge impact on student success in math. The past four years that I have taught third grade, I have tried to lead a positive math community. My research question is *How can inquiry-based learning in Elementary mathematics help create a growth mindset?* I decided to investigate this area because I think educators need to rethink the way they teach math to lead to more success for students in the math classroom.

In chapter 4, I will reflect on my research process. First, I explain my key research findings and how they helped me throughout my project. Within that section, I explain the research that was the most helpful for completing my research and project. Also in my key research section, I will explain the connections I have made through the project process. I explain my new understandings and connections in that section. The next section, I explain the implications for my research project. I will also discuss the limitations for my project.

Following that, I explain possible future research that I may want to do. This will be a big part of my reflection, where I explain what my future and research may look like. The last section, I explain how I will share my findings with others. It is important to think about how to share your research with others, so that they can also use it.

Key Research Findings

When I began my research, I wanted to investigate potential barriers to students' success in the math classroom. Through my teaching and education experiences, I noticed patterns of students thinking they could not be successful in the math classroom. I knew that I wanted to learn more about growth and fixed mindset and how they affect students in mathematics. Two very important researchers in this area are Boaler and Dweck (2015). I knew that I wanted to learn more about their research and apply that to my project.

Dweck and Boaler think that math is a subject that needs rethinking in the mindset of both students and teachers (Boaler & Dweck, 2015). Thinking about math mindset starts with teachers because it will affect the way they teach math to their students. It is important for teachers to reflect on their mindset, as well as model that to their students. Our mindsets are an important factor in our success in school because it helps determine our learning behaviors. Our mindset and learning behaviors can sway our learning outcomes (Boaler & Dweck, 2015).

Boaler and Dweck helped shape the math mindset section of my project. After reading their research, it helped me gain a better perspective on why it is so important for our students and teachers. It is important to teach students about mindsets within mathematics because so many students carry a growth mindset in other areas of their life

but continue to think they are bad at math. In order to overcome that, teachers need to discuss mindset within mathematics (Boaler & Dweck, 2015).

Another finding in my research was how inquiry-based learning can empower students and allow them to grow in different ways compared to the traditional classroom. Inquiry-based learning allows students to grow in areas that they would not in a traditional math classroom. Goodnough and Cashion (2006) discovered in their research three areas that students were able to grow in from doing inquiry-based learning. Students improved working and making decisions in a group setting. The students also mentioned getting better at research and presenting information to their class (Goodnough & Cashion, 2006). These types of skills will help prepare students for future careers. Inquiry-based learning is believed to help prepare students for future learning and potential careers. This type of learning allows students to get experience with coming up with ideas and following through on a plan. Students can get experience with innovation through this kind of learning process (Acar & Tuncdogan, 2019).

Students who have experienced inquiry-based learning in their classroom favored this type of learning because they were an active participant in their learning. The students were more engaged with the learning because of this ownership (Goodnough & Cashion, 2006).

A new connection I have is my understanding on how students learn multiplication. Through my research, I learned more about the progression of multiplication. I learned that the curriculum my school uses does not explicitly follow the progression of how students learn multiplication. I learned through Maryland Public schools progression of mathematics how students learn multiplication. This progression

helped me shape my curriculum, and the pacing of it. My main takeaways is the importance of skip counting. It is important for students to use their background knowledge of skip counting to help them be successful with multiplication (Maryland Public Schools). Skip counting is the foundation for learning multiplication. It is important to give students many opportunities to use their skip counting as a strategy, before they are ready to move onto others. The way our school curriculum teaches multiplication, students are not given many of these opportunities. I will forever teach multiplication differently than I have in the past. After creating my project, I now feel more confident to teach my students multiplication. I hope that my project is a resource others will be able to use.

All the research I completed helped me reflect and think about what I wanted to accomplish in my project. I really believe that if educators take time to reflect on teaching strategies and how they impact student learning, we can then start to see change in our students. I hope that my project is a step in that direction. The next section, I will explain the implications of my project.

Implications

My capstone project has the potential to change the way students learn multiplication, and their math mindset. I believe that if students are taught through inquiry-based learning, students will be more successful in the math classroom. Through my own education experiences, I felt empowered and confident when I was given opportunities to explore my ideas and curiosities.

I also think reflection allows students to process the content better, while also achieving a more positive math mindset. My curriculum is trying to achieve those goals.

Students will reflect on their math mindset and their understanding of the content through their math journals. Hopefully learning math this way will increase student confidence in their math abilities, therefore making them feel more successful.

An implication of my project in my school will be students will learn multiplication in a way that follows the progression of multiplication. The result of that will be students will have a conceptual understanding of multiplication, therefore they will gain a better understanding of the content. Students are given opportunities to explore their ideas to shape their understanding of the content. Multiplication is a very important standard in third grade. Their understanding of multiplication will impact a lot of other areas of mathematics.

I would like to see this change in how math is taught not just in my classroom, but at my school. My plan is to share my curriculum with the principal to hear what her thoughts are. Hopefully parts of my curriculum would work across the elementary classrooms.

Limitations

A potential limitation for my project is teacher confidence in teaching math through inquiry-based learning. Many teachers are uncomfortable teaching this way, or may have never taught it. This could lead to teachers feeling hesitant to teach math through inquiry. Many argue that teachers who are new to inquiry-based teaching may lack the knowledge structures that are needed to tackle the complexities in inquiry (Tawfik et al., 2018).

Another potential limitation is teacher understanding of math mindset and how to conduct these types of activities in their classrooms. Teachers will need to take time to

reflect on their own math mindset and think about how that impacts the way they teach the subject. Educators will need to be open to teaching math this way. It will also be important for educators to be mindful of the language they use with students and how that may affect student learning.

The last potential limitation may be students' resistance to working in a group and learning this way. Throughout this whole unit, students are working together in a group. This may bring challenges to some students. Teachers need to be mindful as to how they create those groups. Some students may have very little experience working in a collaborative team. Due to this students may lack teamwork skills necessary to work in a successful group (van der Vleuten, Cees & Schuwirth, 2019). Many students may not be used to working on problem-based learning in a collaborative group, therefore it may take them time to get used to working as a team (Goodnough & Cashion, 2006).

Future Research

This capstone project has allowed me to reflect on my teaching and my educational experiences. Math was always a subject that presented many challenges for me. It still does at times, however my mindset has shifted. This shift in my math mindset has allowed me to feel more successful in teaching math. In the future, I would like to research more about the math mindset. I want to learn other types of learning strategies that can help students feel more successful in math.

I would also like to further my research on inquiry-based learning and how to embed in other content areas. I think it would be interesting to explore inquiry-based learning in either reading or science. After researching this type of learning specifically for math, it makes me want to learn more about how I could use it in other subject areas. I

think as more teachers research this type of learning more will be willing to try it in their classrooms.

Communicating Results

My capstone project is designed as an introduction unit for third grade multiplication. I plan to share my research and project with my third grade team. I plan to share and discuss my project to see what aspects of it people want to use with our students. My first goal would be to share how we need to change how we teach it due to the progression of how students learn multiplication. We follow our curriculum too much and that needs to be addressed.

I hope that my third grade team will be open to my ideas and embed them into our math classrooms. I think this curriculum has the potential to really help our third grade students gain a conceptual understanding of multiplication. That is so important for students because third grade multiplication sets the foundation for a lot of other math topics.

I think our students and teachers will benefit from my project by students being more successful in our math classes. Students will be more successful due to this new type of learning with a focus on curiosity and reflection. This curiosity and reflection will hopefully help students feel more successful in the math classroom.

Summary

In chapter four, I reflected on the research process while creating my capstone project. While conducting my research, I investigated the following question: *How can inquiry-based learning in Elementary mathematics help create a growth mindset?* After completing my research and creating my project, I think that if we rethink the way math

is taught we will see more students feel successful. It will be important for teachers to give students opportunities to reflect on their learning and understanding of the content. This reflection will empower students. I believe that inquiry-based learning is a teaching strategy that can help empower students as well.

In inquiry-based learning students are in the driver's seat by getting opportunities to ask questions and explore their ideas. Through guided inquiry learning, students are able learn to acknowledge their feelings and thoughts. Through that process students can understand how they learn, and transfer that to future learning (Kuhlthau & Maniotes, 2010). I firmly believe that inquiry-based learning with an emphasis on growth mindset will change the way students view math, therefore our students will feel more confident in their math ability. The way we teach math has continued to evolve over the years. My hope as an educator is we all start to recognize the challenges students face in math, and do everything we can to better support them.

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