Summer 2021

Fostering Critical Thinking Skills, and Engagement to Produce Better Retention of 4th Grade Math

Christine Prostrollo

Fostering Critical Thinking Skills, and Engagement to Produce Better Retention of 4th Grade Math

by

Christine Prostrollo

A capstone submitted in partial fulfillment of the requirements for the degree of Masters of Arts in Education.

Hamline University

Saint Paul, Minnesota

August 2021

Capstone Project Facilitator: Jana Lo Bello Miller
Content Expert: Zachary Gonsioroski

ACKNOWLEDGEMENTS

To my husband and kids who have supported me along every step of the way. I couldn't have done it without you.

TABLE OF CONTENTS

CHAPTER ONE

Introduction

Overview of the Capstone Inquiry

The purpose of this project is to explore a math curriculum for 4th-grade students that is grounded in best practices, resulting in long term retention of math concepts and optimizes a students' critical thinking skills for future math application. In my experience of teaching mathematics, there are several approaches to teaching and learning mathematics. Many of these approaches are strong in theory, but not practical in the classroom where standards and state assessments are frequently tested and heavily valued. In comparing the results of math taught with conventional practices as opposed to math taught through inquiry, the most effective instruction will be shown to be superior for its ability to provide a more relevant standard of accomplishment when driven by deep thinking and engagement. The research question is: *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st century?*

Chapter One is an exploration of my personal experiences with teaching mathematics. It begins with why this topic is important to me as well as of great relevance to the teaching of mathematics. I discuss the need for research about the balanced teaching of mathematics and examine different inquiry instructional strategies. Best practices are reviewed as I explore them in terms of their successes and failures. The final section outlines the remainder of the capstone project.

Importance of this Capstone Project to the Writer/Researcher

Watching my peers learn things faster than me has been a lifelong experience. The only time I felt successful was when the subject was math. I did not always get the right answer the way it was taught, but I got the right answer. Math made sense to me. After studying my own experiences with math, I came to the conclusion I was able to think about math in ways different from my peers. I discovered in myself that I am able to critically think about a problem, which helped me in the classroom.

I obtained a degree in elementary education with a concentration in math. At the time, I was convinced I could only teach elementary school, and logically, I picked something I was good at: math. During my first years of teaching elementary school, I fell in love with teaching math. When I sat in professional development meetings and heard other teachers complain about teaching math, I would laugh to myself because I thought math was fun. When my husband and I had to move for his job, I initially had a hard time finding a job teaching elementary school, but I noticed there were plenty of middle school math job openings. Happily, I took my first middle school job in my third year of teaching.

Teaching middle school math revealed the different ways teaching math is approached. My first middle school math job used a curriculum called “Connected Mathematics Problem” (*What is CMP*, n.d). The curriculum was different from anything I had ever used. It was a problem-centered math curriculum that focused on student inquiry and not on teacher instruction. It was my first introduction into problem-based learning in mathematics. I found parts of the program powerful and engaging to some students, but observed a complete disconnect with others.

My husband and I moved again, and I found myself in a new middle school. This school used a more traditional approach to teaching mathematics. Teachers would work through a textbook and engage in a lecture format. I felt restricted from teaching math in a more engaging way because of the expectations for my students to do well on state assessments. I could only follow the book and cover the standards; hence, there was no time to explore or teach math another way. I saw that students memorized the information well, and could pass the test; however, when I would refer back to a topic, they looked at me with blank stares.

When I decided to make a shift back to the elementary classroom, my ideas of best practices for math were blurred and conflicted. In my heart, I knew there was a better way to teach math. I thought it could have been somewhere between the two different teaching styles I had experienced and practiced.

My new school district embraced a guided math program and with a curriculum called Bridges that I found lacking in many areas. I felt that there was not enough material to successfully teach the skills. I also felt that the material was not engaging for the students. I found myself researching and developing new lessons. I wanted my students to be engaged, find math exciting, and most importantly, provide ways for them to learn. On my journey to find the best way to teach math, I wanted to know what was the best way to teach math. If the standards could be taught in a way rooted in problem solving that promoted deeper understanding and allowed students to make connections that made sense and lasted, I would find it.

Teaching Mathematics in a Way that Promotes Student Learning

Introduction

I have been teaching for 12 years and have dabbled in several teaching approaches. I have had moments of great success and moments of complete failure. At the end of each year for my 4th-grade students, I reflected on my teaching, and ultimately felt that my students were ready for the 5th grade. Alas, when I overheard the 5th-grade teachers in the workroom comment on the fact that their students did not remember anything from 4th grade, I knew the teaching and learning process was flawed, and I questioned if I could have done more. It made me wonder how I could make learning more meaningful for my students to promote student learning.

Deep Thinking and Engagement

When I think back to my own learning experience, I know that the topics I was more proficient at were the topics I embraced the most. I have a wealth of information when it comes to US Presidents not because I was taught it in school, but because I absorbed that learning and embraced it through research. I can add and subtract fractions quickly, not because I am good at math, but because I love baking and often need to change the recipe. I know that learning happens when it is interesting, engaging, useful, and fun.

I know that I learn best when I experience learning through meaningful experiences. I noticed in the classroom that students connected to learning the same way; yet, the way we teach does not always reflect what we know works. I felt a constant pull between doing what I knew was best for students and ensuring I covered the standards. There was also an added pressure to mimic what other teachers were doing to ensure all

are able to plan together, as well as ensuring that we covered all the curriculum before the end of the year whether it left some students behind or not. I concluded that it is no wonder that our students do not connect to some or all of the lessons because we rush the learning process.

When I talk to my students today about a problem they are working on they look at me as the answer keeper. They ask questions to gauge my response to see if they are correct or not. They are not having natural conversations about mathematics. If the problem presented is about sharing 13 cookies with 2 people, they ask, do I divide, or will I have a remainder? To me, students should read the problem and picture a plate of cookies and figure out how to share it with a friend. Instead, I find the need to prompt them by asking “What would you do if you had a plate of cookies to share with a friend?” When presented that way, students almost always say, "We can split the leftover cookie in half and each get 6 ½ cookies." They are able to solve the problem because they think about it in a way they can relate to.

These observations beg the question of how do we create lessons that allow students to holistically think about math? If we can make the math more practical and real, will they be able to connect to it, and if so, will they be able to retain it? As I think about teaching math, I picture the moments that have been successful for me. Those moments usually revolve around a story to help students visualize a situation. With the stories, students can picture the problem and are able to find a place to start. I also know that discourse and critical thinking work together to make sense of situations. With that idea in mind, I believe that the best way to do math is through some form of inquiry. In

this research effort, I will compare the inquiry instructional strategy and how best to implement it into the classroom depending on the concept being taught.

Effective Inquiry Instructional Strategies

A quick Google search of best instructional math strategies provides a conflicting and confusing body of data. There is a plethora of information about different strategies and the implementation of them in the classroom. In this capstone, I focus on inquiry-based math as opposed to direct instructional math strategies to determine which constitutes a best practices approach for 4th-grade students. Some of the inquiry strategies that are explored are problem-based learning, design thinking, and SCAMPER (substitute, combine, adapt, modify, put another use, estimate and revise). The idea behind all the inquiry strategies is to support learners in working together through the problem solving process. They have proven to be successful because they promote creative thinking on given topics (Rhodes, 2017). Through my years of teaching mathematics, I have seen the value in teaching through inquiry. I will incorporate inquiry learning in my math curriculum that I create for my students. Since not all inquiry is the same, one must understand the different types to better understand when and how to implement them into the classroom. The five levels of inquiry are as follows:

Confirmation Inquiry. In this model, students are given the question, method of reaching the answer, and the answer (MacKenzie, 2016). Students set out to find why the method works. This might be used when students are presented with an algorithm. They spend their time justifying why the algorithm works, not memorizing the steps.

Structured Inquiry. In this model, students are given a question and a method to solve it. Often, structured inquiry is led by the teacher. The teacher poses a question and

the students work together to solve it (MacKenzie, 2016; Rooney, 2012). For example, a teacher may give a group of students 12 tiles. The students are then told to make as many arrays as they can. The class would then have a discussion about factors.

Guided Inquiry. Guided inquiry is when a teacher poses a question, but does not tell students how to get an answer. Students typically work in groups to think through the problem and develop their own statements on how to solve the problem (MacKenzie, 2016; Rooney, 2012). For example, a teacher may give the students that are new to division a problem such as 72 divided by 6. Students work together to solve the problem in as many ways as they can. They then share their division strategies with the class.

Open Inquiry. Open inquiry is when students develop their own question and ways to solve it (MacKenzie, 2016; Rooney, 2012). "Problem Based Learning" is a popular way to use open inquiry. An example of open inquiry is if a student wants to find out how many books are in the library. They would develop a way to calculate it based on how large the bookshelves are, how many books are on each shelf and how many bookshelves are in the library. This is a completely student-driven approach.

Coupled Inquiry. Coupled inquiry is when two types of inquiry are used. For example, the lesson may start with a guided inquiry and then be an open inquiry (Rooney, 2012). This may be used to get students to have a better understanding of new concepts before they are sent on their way to discover answers to their own questions.

Since inquiry in mathematics is different from the way most students have been taught, students need to learn to think and engage within a math classroom differently. Students no longer can sit back and gather information. They are required to actively engage in the task at hand. This shift requires students to be mathematical thinkers and

doers. The literature review evaluates the pros and cons of inquiry learning and direct instruction and the best practice for desired outcomes.

Summary

As I work with students, it is my goal to help them develop skills they can use in the future. I want them to be able to think about math critically and naturally. I want them to learn to question and to understand what they are experiencing. It is my hope that students walk away knowing they can solve hard problems and that they do not need an answer keeper to tell them they are right. My goal is to learn the best practices to teach, and to create a curriculum that will best support my learners whether through traditional instruction or inquiry-based approaches.

In Chapter Two, I will analyze research that supports my question, *Which instructional approach better fosters critical thinking skills, engagement, and long-term retention in 4th-grade students?* The chapter contains an analysis of different levels of inquiry and ways to develop problem-solving and critical thinking skills. I will explore the unbalanced and incomplete literature about the best practices to teach mathematics to 4th-grade students, and when are the best times for those strategies to be used.

Chapter Three provides a 4th grade curriculum that can be used in the classroom to promote critical thinking skills, engagement and retention based on the information gathered during the literature review. Finally, Chapter 4 provides a reflection of the capstone project.

CHAPTER TWO

Literature Review

Introduction

In education, teachers spend hours each week designing lessons that they hope will invoke learning. The learning process is deeper than sending out information for students to take in. There is a delicate dance between creating lessons that are thought-provoking and engaging, and delivered in a way that is remembered. The following literature review is to discover a solution to the research question: *Which instructional approach better fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st centur*y? This research will be used to develop a curriculum that is research-based and will help students to foster critical thinking skills, increase engagement and produce long-term retention of mathematical skills.

Critical Thinking

One of the most challenging notions facing educators today is how to best prepare students for the 21st century (Gasser, 2011). It has been said that we are preparing our students for jobs that do not yet exist. Students will be required to do far more than rote memorization; they will need to be able to have the skills needed to think deeply about a problem (Ritchhart et al., 2011).

Critical thinking is at the core of those skills required to be a successful learner. If we are successful in developing the critical thinking skills of our students, they will then reach a higher level of problem-solving ability. If they reach this level of problem-solving ability they will then naturally obtain a greater understanding and knowledge of

mathematics (Ritchart et al., 2011, p.10). In this chapter, I explore what critical thinking is, how to foster these skills in a classroom, the importance of engagement in problem-solving, and which instructional methods are most successful in doing these things to achieve long-term retention. If we want students to learn, then we must spend more time having students learn the skills to do the subjects than learning about the subject (Ritchart et al., 2011, p.15). Students need to learn how to think critically, problem-solve, and apply their understanding.

What is Critical Thinking

Critical thinking is a skill used every day. We need it to function in our daily lives. Critical thinking is very complex and has many definitions. Siegel (1988) summarized critical thinking as "...thinking [that is] appropriately moved by reasons" (as cited in Bartell et al., 1997). When we think critically we are able to think about possible outcomes and make a good decision. Critical thinking skills help us in the basic daily tasks. Decision making is an important part of adult life. Studies show that the earlier children learn to think critically the better equipped they are in school and as they enter their adult life. With an ever-changing world, the best practices of education need to evolve and adapt as well (Critical Thinking, n.d.).

History of Critical Thinking

In the book *California Teacher Preparation for Instruction in Critical Thinking: Research Findings and Policy Recommendations* by Bartell et al.(1997), there is a detailed history of critical thinking and the impact it has on our world today. From this history, it is clear that critical thinking is not a new concept. The most common strategy to promote critical thinking is called “Socratic Questioning.” The origins of this strategy

can be traced to 2,500 years ago when Socrates first established his method of asking probing questions. He felt it was of the utmost importance to support beliefs with evidence, reasoning, and understanding of basic concepts (as cited in Bartell et al., 1997).

Following Socrates, many great influencers challenged ideas and common beliefs. Individuals challenged the norms of society and sought meaning and understanding at a deeper level. The Middle Ages interweaved critical thinking ideas in their writing and teachings. Aquinas showed us the power of reasoning and that we must not challenge all beliefs, but to challenge the beliefs that do not have merit. The Renaissance challenged people to think more deeply about the arts and things that bring people joy (Bartell et al., 1997).

In 1906, Sumner shared his findings and stated that humans are prone to think socio- centrically, and therefore, teach the way that best supports others like them. This can be dangerous because ideas are not challenged. Sumner stressed the importance of critical thinking in education, and that teachers have an important role to create good citizens. After Sumner, John Dewey, Ludwig Wittgenstein, and Piaget emerged supporting Sumner's original findings and emphasized the importance of teaching critical thinking skills (Bartell et al., 1997).

During the 1970s, Freire wrote a book titled, *Pedagogy of the Oppressed*. In this book, Freire introduced the idea of problem-posing education, the basis of which is to use a problem-posing model instead of the more traditional approaches to teaching (as cited in Mishra, 2015). Freire felt that teaching was turning into a "banking model" where students were empty containers and teachers needed to fill them with knowledge. In a banking model, information is memorized, not learned (as cited in Behizadeh, 2014).

For thousands of years, the great names of the past have studied, questioned, and challenged the world around us. They taught us the importance of thinking deeply and asking questions to better understand information. It is not enough to just "think": if we want to truly understand, we must think critically. The great philosophers have taught us that if we want to teach mathematics, then we must focus on reasoning and critical thinking (Bartell et al., 1997). People like Freire propelled how we thought of education and the purpose of the classroom. Students are there to think and experience learning, not simply be passive receptacles for information.

Critical Thinkers vs. Passive Thinkers

To truly understand what critical thinking is, one must understand what critical thinking is not. It is not passive thinking. Passive thinking is allowing information to arise. Critical thinking is actively thinking; it is engaging in the thinking process, questioning, and exploring. Most teachers who teach on the surface, are focusing on memorization of information and facts. Usually, this is done through relative practice. When teachers teach deeply, they focus on developing an understanding through a hands-on approach (Ritchhart et al., 2011, p. 7). Studies of how the brain works show us that if material is learned at a deeper level, then synapse fire makes a lasting connection in our brain. When material is taught at the surface level, the synapse creates a weak connection and information will be easily forgotten (Boaler, 2016, p. 1).

Banes (2006), a kindergarten teacher, noticed the difference when she changed the way she did the morning calendar with her kindergarteners. Students were passively thinking about the calendar as they watched their teacher count the days. Barnes created active thinkers when she changed the calendar to include days and moments that mattered

to them. One student wondered how many days until Santa came. So the students counted how many more "sleeps" until the big man came. Moments where students can question, connect and engage in mathematics are moments where students shift from passive thinkers to active thinkers (Barnes, 2006).

Ways to Foster Critical Thinking

As we prepare students for the 21st century, we must take into consideration the skills needed to be successful. Each year, students become further disconnected from mathematics and the importance of math in the real world (Diego-Mantecon et al., 2018). Students spend countless hours learning rules for math they will never use (Boaler, 2016, p. 27). Classically, there was a purpose for the memorization of formulas, but that purpose no longer exists with the access to cell phones and the internet. If we prepare students for jobs that can be done by a computer, they will not be able to maintain a job (Pink, 2016). When the top 10 Fortune 500 companies were asked which skills they valued the most, the top three skills in 1970 were writing, computation skills, and reading skills. When asked in 1999, they ranked those skills at the bottom, and instead listed teamwork, problem solving, and interpersonal skills (Boaler, 2016). The world is changing, and with that, our teaching needs to change to keep our students relevant in the workplace. Students must be able to critically think, problem-solve, communicate, and work with others (Gasser, 2011).

Problem Posing Education. In an effort to help students develop critical thinking skills, teachers have switched their teaching style to Freire's model of problem posing education. There are many different approaches to problem posing education. Some of these strategies include inquiry learning, problem-based learning, design thinking, or

SCAMPER. They have proven to be successful for increasing students' critical thinking (MacKenzie, 2016; Rhodes, 2020). Each of the strategies are unique in their own way, but they all share a few common traits. They are all rooted in using quality questioning to drive instruction and collaboration.

Quality Questioning. It is not enough to pose just any question. Teachers claim to already be teaching using problem solving, but in reality the level of questions is less than par. When a question only requires basic skills, then it is not a quality question. Often, quality questions are open-ended. Open-ended questions push students beyond basic skills and knowledge and push them towards a deeper understanding. Since no one answer is correct, students can solve a problem that they can connect to (Ritchhart et al., 2011 p. 30; Nugent, 2006).

If students spend more time answering questions that someone else asks, there is no purpose for them to want to know more. Questioning is the most important thing to do to ignite critical thinking. One question leads to another question; it is a chain reaction (Nugent 2006). Good quality questions spark curiosity, and curiosity is the driving force to wanting to know more. Since there is not one single right path to get to the answer, students can solve it in a way it makes sense to them (Ritchhart et al., 2011, p. 13; Nugent, 2006, p. 287). Teachers sometimes hesitate with the idea of presenting challenging problems at the start of the unit. Teachers worry that if the information is too hard, students will be stuck and not able to solve it. Hoffer challenged that if you give the students an exciting problem at the start of a unit you create the urge to “know” (Hoffer 2012, p. 41; Ritchhart et al., 2011, p. 13). This urge is a driving force for students to learn the material.

Visual Representation. Word problems are an important part of understanding mathematics. It is a chance for students to apply their knowledge to real world situations. However, not all students are successful problem solvers due to factors such as a low working memory (Swanson et al., 2013). Working memory is necessary for being able to solve problems because students must hold information in their heads as they work out and sort through the problem. Studies show that to best support students with math difficulties teachers should provide visual representation and even with visual representations, some students with a lower working memory will still struggle. Other strategies that have shown to help include, diagramming, identifying keywords and developing metacognitive skills. Even with additional support, some students may struggle due to the limited capabilities of their working memories (Eckenrode, 2016; Swanson et al., 2013). It is important to be equitable to all learners; additional teaching strategies may need to support students with math difficulties.

In the book *Making Thinking Visible*, the authors stated, "When we make thinking visible, we get not only a window into what students understand but also how they are understanding it" (Ritchhart et al., 2011, p. 27). When students talk about what patterns they are noticing, teachers can help them to visualize by listening to them and then recording their thinking using mathematical notation (Johanning et al., 2009). When students start to use visual representation they are not only helping themselves understand the material, but those around them as well. As an educator, we have an opportunity to see and listen to what our students know, to help them dig deeper, and think more critically to further develop their understanding. This, in return, gives students another

chance to engage with the material and continue the learning process (Ritchhart et al., 2011, p. 27).

To best prepare students for the 21st-century, students must be able to think critically and problem solve. Research in this section proves that inquiry learning supports the development of critical thinking skills. Through questioning and exploring topics, students are able to develop the deeper understanding of mathematics that is vital to prepare students for the future. Research results indicate that not every child is successful in inquiry-only instruction (Elfstrom, 2018). Students may need different teaching strategies such as visual representations to support learners who lack working memory when working with word problems (Swanson et al., 2013). Students that have learning disabilities may need additional structure to support lacking prior knowledge (Elfstrom, 2018). Critical thinking is not the only thing that must be considered when preparing students for the future; creating an environment that promotes engagement is just as important.

Engagement

Research shows that critical thinking skills are not enough. In the medical field, students learn through problem-based practices. They are faced with real-life problems that do not always have one solution; yet, students are driven to know the answer. Students are not just using their critical thinking skills, they are engaged in the process (Behizadeh, 2014). Similarly, true successful development of a student's mathematical knowledge requires engagement in the learning process (Gilbertson, 2017). One of the key elements for helping students to learn mathematics is making math enjoyable (Gasser, 2011). It is generally accepted that some students do not like math, nor are they

good at it. In fact, math is the only subject that has its own form of anxiety (Elfstrom, 2018). Often, students have a preset notion that they do not like math or that math is not fun. Studies show that the brain will not learn if it is not enjoying the process (Jensen, 2000). Math anxiety disappears when students find confidence, are engaged in the learning, and feel successful (Boaler, 2016, p. 145). It is important that students are excited to be learning, they are connected to the subject, and they have time to explore, question, and think about the topic. We must provide thought-provoking activities that drive mathematical discourse and collaboration among their peers.

Making Math Fun

Over time, math has developed a bad reputation. It is generally accepted that someone is "bad at math" or they "can't do math." Math anxiety starts at an early age if students are not given the opportunities to explore math in a non-threatening way. When students are rushed through the learning process, they feel inept at mathematics (Elfstrom, 018). However, recent brain research proves this is not true; anyone, and everyone, can learn math. Math is viewed differently than other subjects because it is viewed as a performance task (Boaler, 2016, p. 21). You either get the right answer, or you do not; you are either good at math or you are not. One thing that teachers must help students see is that math can be fun and enjoyable. Research shows that students are more likely to be engaged in learning when the focus is on understanding a subject matter and not on performance (Ames, 1992, as cited in Thomas, 2000). Students are more likely to be engaged when they are a part of the learning process. Inquiry learning allows the students to explore concepts. Learning is an active process that happens when past

knowledge connects with new information, and this process requires engagement (Rooney, 2012; Wu & Lin, 2015).

Connecting Students

If we desire to create 21st-century learners, then we must teach in a way that excites and connects the learners to find the "beauty in mathematics" (Boaler, 2016; Gasser 2011; Rhodes 2020). The first step to do this is to get students to question and explore math as part of a bigger reality. Students must feel a purpose and reason for the problem at hand. Students learn when the teacher presents them with opportunities that thrust them into a situation where they want to learn more (Johanning et al., 2009). Most students do not care how many legs and how many heads are on a farm, but they may care about how much money they need to start up a video game business.

Modeling is a term used to describe the type of problem solving students need to be doing. Modeling is when a teacher presents the class with a real world problem. Students then go through a questioning process, similar to other forms of inquiry. The biggest difference is that modeling is a problem that exists in the real world; it is not made up to facilitate learning. This is authentic in nature, and because of this, there may not be one set answer, but because of this, a different kind of learning is happening. Students are able to see the purpose of math outside the classroom and connect to the real world, sometimes even at the global level (Magaletto, 2002; Wiemken et al., 2021).

An educator's ultimate responsibility is to prepare students for the real world. Good questions connect students to the world around them. Students draw on prior knowledge and are able to apply it to a new situation (Ritchhart et al., 2011, p. 14). There is a right balance of connecting to students' interest at the same time maintaining focus on

what is being taught. High-interest questions with the right amount of rigor can engage students and make math more meaningful (Gasser, 2011). This strategy will also provide students with an opportunity to think on a more global level and hence, foster critical thinking skills. With the ever-changing world, these skills are necessary to allow students to go beyond basic knowledge and develop higher-level thinking (Rooney, 2012).

Connecting math to students' lives is essential. When students feel a disconnect to the topic they are learning they will not retain the new learning. Math can sometimes feel as if it is a set of unrelated rules and ideas (Diego-Mantecon et al., 2018). Connecting learning to students' interest, the real world, and other subjects helps to bridge the gap between math and the world around them. Well-designed questions spark curiosity and make students want to know more (Barnes,2006; Gilbertson, 2017).

Students' Interest. One way to make math enjoyable is to connect topics to student interests. According to former NCTM president Seeley, students will be more engaged in learning when the math feels real to them. Teachers can connect students to math in the real world through the use of popular media. Most students already have an interest in social media, movies, shows, and music, so why not show them the math behind it? There are moments in teaching where students will benefit from practice and a more direct approach to teaching. In these cases, students will learn best when it is presented in a way that connects to their own lives and interests. For example, students can watch movie clips such as Abbott and Costello's *In the Navy* where there is a scene showing how many donuts each person will get. Students can use their own understanding of division to prove how many donuts the men will get.

Meadows and Caniglia suggested getting students to not only think about the way mathematics is represented correctly, but also by the way it is done incorrectly (Meadows, & Caniglia 2021). There is power in proving mistakes that not everyone catches. When students see math portrayed in the media it not only gives them a chance to see how it connects to the real world, but it makes learning math "cool" and less intimidating.

Real World. The fourth Common Core State Standard for Mathematical Practice (SMP4) states the need for students to explore mathematical concepts through real-world application:

> *Mathematically proficient students can apply the arising mathematics they know to solve problems arising in everyday life, society, and the workplace. They routinely interpret their mathematical results in the context of the situation and reflect on wherever the results make sense, possibly improving the model if it has not served its purpose.* (p. 7)

Not only do the standards express the importance of getting students to see the mathematical purpose in the real world, it is another way to increase students' interests. Modeling is one example of making real-world connections for students. Modeling is when students look at real-world phenomena and question, predict, and analyze solutions (Magaletto, 2021; Wiemken et al., 2021). Students are forced to struggle through a problem that may not have an answer. They are actively thinking and understanding the world around them. These activities ignite students to think critically and to use problem-solving skills sometimes even at a global level, providing students with a chance to see that the world is much bigger than their community. They can explore concepts

that impact others, which in return helps develop well-rounded students. These cross-cultural conversations allow students to deepen their mathematical understanding and build empathy for others (Wiemken et al., 2021).

Cross-curricular. Traditionally math is taught in isolation to other subjects. In all other subjects, students are required to use their understanding of other subjects or build upon previous learning. In mathematics, concepts can be taught in isolation, making it hard for students to see how concepts are related to one another. When math is taught through problem solving, rarely can topics be explored without the use of other subjects or concepts being interweaved (Nugent, 2006). When subjects are taught in an interdisciplinary approach it has many benefits, especially in mathematics, because it helps to build more than mathematical understanding it helps build lifelong skills, such as critical thinking and problem solving. STE(A)M, an acronym for science, technology, engineering, arts, and mathematics, education has proven to help students to understand complex concepts and make meaningful connections between subjects (Diego-Mantecon et al., 2018). When both sides of the brain are being used, learning is enhanced. The right side is primarily used when working with math, but when the left side is also engaged it helps us to foster creativity and make students better problem solvers (Gasser, 2011).

Movement

One way to promote engagement is through the use of movement. Movement gives the brain a break, so it can take in more information. Studies of animals have shown that brains form maps of information that is collected. The scenery at which the information is retrieved helps create the map. If a student is learning throughout the room, the brain is constantly rewiring, allowing information to form strong connections.

This memory system is called “episodic encoding” (Jensen, 2000). In animal studies, it was found that the brain forms maps based on scenery, but also its body's relationship to that scenery (Fordyce & Wehner, 1993, as cited in Jensen, 2000). In activities when students are moving around a room, they are not only going to be more engaged, but their brains are more likely to learn the information better. As well, students often need to feel the learning through hands-on activities. When students work with manipulatives they are stimulated both physically and mentally and it allows them to experience firsthand the concepts with which they are working (Wu & Lin 2015).

Collaboration

Humans are social animals and benefit from working with others. Studies have shown that students that work together can significantly boost student achievement (Hoffer, 2012). When students work together they discover they are not alone in their struggle to understand new concepts. One idea leads to another idea and students can build upon one another’s understanding (Allmond et al., 2010). When students work together they discuss, reason, and justify their thinking. This process helps them to solidify their own understanding and in return helps them to better understand what they are learning (Odegaard, 2015). Another benefit arises when they become comfortable working with others and pushing each other to think differently and explore other possible solutions. This process further helps students to develop critical thinking skills, while learning to work with others is a lifelong skill that helps them no matter what path they take in life (Magaletto, 2021). One lifelong skill that is needed is the ability to communicate effectively with others. Learning to communicate in the math classroom

helps students to develop the skills needed to share ideas, listen to others, and have a successful conversation even when ideas do not align.

Mathematical Discourse. Mathematical discourse is very important in a math classroom. Since students desire to communicate with one another, it is beneficial to incorporate it into the classroom. Well-designed discourse can engage even the most reluctant of learners. It gives everyone a purpose and sense of belonging (Hoffer, 2012). When students collaborate they realize that they know more when working together than working alone. It is an opportunity to hear others' ideas, share their own thinking, and push one another to a better understanding. A community where rich dialog is valued promotes an environment where students feel they can take risks and explore ideas deeper. Working together is a skill that students will benefit from regardless of the path they take in life because it fosters critical thinking and reasoning (Elfstrom, 2018; Hoffer, 2012; Magaletto, 2021).

Providing students with a chance to talk in class also promotes language development. This is especially true for English language learners. In a 10 year span, 7 states saw a 300% increase in the number of English language learners enrolled in schools. Working with peers may present some difficulties at first, but helps build confidence and language acquisition. Studies show that students that struggle in language development are more likely to struggle with numeracy development. These studies stress the importance of incorporating language as part of the math instruction. (Eckenrode, 2016). Language is best learned through doing and practicing with their peers (Eckenrode, 2016; Hoffer, 2012).

When trying to get students engaged in learning, inquiry instruction seems to be most effective. It provides students a chance to explore topics with their peers. It also develops collaboration skills that are beneficial for lifelong learning. Inquiry instruction takes time to prepare and to implement in the classroom (Rooney, 2012). At times, students may need a more direct approach to learning concepts, skills, or processes, but it should be done in a way that is engaging and will connect the learners (Allmond et al., 2010). The next section explores what instructional strategies best support students in regards to retention of information.

Retention of Information

Learning is a process. It is best achieved through the development of critical thinking skills within a curriculum that promotes engagement for their students. The ultimate goal however, for a teacher and a student is retention. Teachers want students to remember the material being taught. Perkins, the author of *Safe Schools,* stated that retention and understanding only happen when students are thinking about what they are learning. From learning, they gain knowledge, which leads teachers to wonder what the best way is to promote learning in the classroom.

Teachers often struggle with the pressure of time. In 4th grade, there are 27 math standards to teach. The pressure begins when it is expected that all standards are covered in March before state testing. Teachers know it is important to give students time to dive deep in the material, but they also know they need to move quickly to cover the standards. Teachers shift in doing what is best for students learning to teach basic skills in isolation to ensure all content is covered before the test (Behizadeh, 2014). Ultimately, teachers need to decide, do they choose to teach in a way that allows students to develop

critical thinking skills through engagement, but maybe not cover as much material, or do they teach in a way that concepts are covered and in a "tell and practice" kind of way (Richhart et al., 2011, p. 9)? High stakes tests place pressure on students to perform, and in return, teachers are judged based on the student's ability to show what they have retained throughout the year. The way in which teachers deliver the information and have students practice in the classroom will ultimately determine if a child is able to retain information or not.

Understanding the Brain

There are many factors that come into play when considering if something will be remembered for a long period of time or not. The first thing that must be considered is understanding how the brain works. By understanding the process of learning and remembering, we have a better understanding of teaching and learning. Our brain fires synapses, and each synapse makes connections to other parts of the brain. Each time the brain is forced to work, the deeper the learning, and the stronger the connection. If a skill is learned quickly or through memorization, the synapse may not last because it is not as strong (Boaler, 2016).

Growth Mindset. Evidence tells us that anyone can learn math in the right environment; the difference is if students have a fixed mindset or a growth mindset. A fixed mindset sets limitations on what the student will be able to learn. They give up quickly when things get challenging or when they feel they cannot figure it out. A growth mindset allows one to feel as if they can tackle any problem. If students have a growth mindset, they are able to take on learning challenges and in return allow their brains to grow. Our education has programmed people to believe that only certain students can

learn certain things. This is false. If teachers create an environment where learning is possible, the brain will grow in ways we cannot predict (Boaler, 2016).

To foster a growth mindset, the classroom should be set up in a way that allows students to feel comfortable making mistakes. If students are placing themselves in vulnerable situations to try challenging problems, they must know it is all right to do so. Creating an environment that says mistakes are what makes the mind grow, students will be more open to trying new things. There is value in struggling and failing to get the right answer. Tasks should model a low floor, high ceiling approach. The problems should be easy enough to access, but high enough to let students grow. Through challenging tasks, students' brains will have an opportunity to grow and make connections (Boaler, 2016, p.177).

Hippocampus. Another important part of the brain is called the hippocampus. The hippocampus is where information is stored while it sorts the information to send to the long term memory part of the brain. The hippocampus can only hold so much information at any given time. If too much information is sent there at once, no learning will occur. The brain needs breaks to be able to function properly (Jensen, 2000). Under the right conditions the hippocampus has proven to grow significantly (Boaler, 2016, p. 3). The hippocampus decides to keep or get rid of information based on two things: significance and novelty. It stores information for months before it moves it to the cortex (Spitzer, 2006).

Cortex. This is another part of the brain that helps store information long term. This part of the brain is driven by rules. It shows growth during learning, but does not learn new information as quickly as the hippocampus. Rules are developed over time and

are based on generalizations and not details. Our brain takes in information and strengthens its understanding based on examples and is applied to new learning. The cortex is also responsible for creating mapping pathways (Spitzer, 2006).

Noradrenaline and Dopamine. One of the best ways to provide breaks to the brain is through movement because it releases noradrenaline and Dopamine. Noradrenalin occurs when students have a sense of urgency, this can occur through compensation such as activities. Risk-taking activities such as trying to solve a challenging problem also releases noradrenaline in the brain. The release of dopamine occurs during social interactions that result in positive feelings. These chemicals stimulate the brain, allow more information to be stored and retrieved (Jensen, 2000). Further supporting the idea that math should be fun and engaging.

Learning about the brain helps us to have a clearer understanding of what is happening during the learning process. Once we know how the brain works and how it stores information we can create an environment that is conducive to remembering new learning.

Approaches to Instruction

If the ultimate goal in teaching is to teach new learning that is remembered and can be applied later, then we must pay special attention to how we deliver the information. There are two main approaches: inquiry and direct instruction. Inquiry draws upon the ideas of constructivism that posits that learning is an active process and students must construct their own ideas based on what they already know (Rooney, 2012). Direct instruction follows the banking model of teaching where teachers present information and students take in all that they can. In one approach the teacher gives

information, and in the other the teacher and students work to find the information together (Behizadeh, 2020). According to the Knowledge-Learning-Instructional Framework (KLI), deciding on which instructional method to use should be based upon what the teachers' learning objectives are for that lesson (Yeo & Fazio, 2018).

KLI is a framework that is rooted in understanding how the brain learns and stores information in different learning approaches. It is focused on two types of learning approaches: first, an instructional and assessment approach that promotes the ability to recall facts from instruction. The success of this approach is measured with how well a student answers questions. The second approach is focused on the learning process and desired knowledge components. The KLI framework suggests that this second approach is most critical for long-term retention. Within these two learning approaches, there are three main mapping events that can occur during the learning process, they are constant-constant, variable-variable and constant-variable mapping (Yeo & Fazio, 2018). To better understand this framework, one must understand the mapping that occurs in our brain during these different events. The following are explanations of each of these events:

Constant-Constant Mapping. A constant-constant mapping situation in mathematics is when the same rule is applied every time. For example in mathematics, the area of a circle is always $A=r^2$. No matter what, this is always true. It is a linear connection in the brain. In situations when teachers want students to learn something that is recalled primarily by memorization, the best instruction strategy is through repeated practice. Typically through direct instruction, students are more likely to recall this information for long periods of time (Yeo & Fazio, 2018).

Variable-variable Mapping. A variable-variable mapping situation is when the concept being learned may not always apply to a given situation. For example, when adding fractions you must change the dominators to add correctly. Variable-variable mapping is a more difficult process that requires multiple steps. It is more of a zigzag line in the brain. When concepts being thoughts are variable-variable situations it is best to teach in an inquiry approach. Where students have a chance to apply rules to various situations and make sense of what is happening (Yeo & Fazio, 2018).

Constant-Variable Mapping. A constant-variable mapping situation is when the concepts being taught are generally true, but have exceptions to the rules. We see this in division. The constant is the mathematical process of division, and the variable is what to do in the case of a remainder. An example of this is when a problem was given on the National Assessment of Educational Progress, that asked students to solve how many buses were needed, given a specific number of people. Only one-third of the students were able to provide the right answer because they were unsure of what to do with the remainder (Eckenrode, 2016). In these situations, you may need a balanced approach to instruction which may be some direct instruction followed by inquiry instruction or vice versa.

There is a push in education to teach strictly through inquiry. Spitzer warns that it can be counterproductive. The brain creates rules based on generalizations that are created through practice examples. This should be part of learning every day (Spitzer, 2006). A report on findings from the National Center for Education Statistics found that inquiry learning is especially hard for students with learning disabilities due to the lack of structure to access prior knowledge (Elfstrom, 2019, as cited in Poncet, 2010).

The counter argument is that teaching strictly through direct instruction can be harmful for students because it builds frustration, misunderstanding, and confusion (Elfstrom, 2019, as cited in Poncet 2010). Inquiry learning has proven to successfully improve student's critical thinking skills and demonstrates a better understanding of factual content. In a 3-year study comparing problem-based learning schools to traditional schools, the students that learned through inquiry did three times better on rote knowledge and mathematical concepts (Thomas, 2000). Uniquely, girls tend to do better at learning through inquiry than more traditional approaches. Boaler suggests that girls prefer to learn in a way that focuses on understanding not memorization (Boaler 1997, as cited in Thomas, 2000).

Using different instruction methods provides a balanced approach to instruction. One should target the desired outcome with the type of skill that is being taught. Bearing in mind that the more complex concepts may require a flexible approach to instruction (Yeo & Fazio, 2018), for example, when teaching division. There are benefits to working through problems with students through direct instruction because it improves their understanding of the division process. While providing problem-solving activities through inquiry learning helps students to remember the procedure.

Summary

Throughout this literature review the importance of critical thinking, engagement, and retention were all investigated as significant components in the learning process in efforts to answer the question, *Which instructional approach better fosters critical thinking skills, engagement, and long-term retention in 4th-grade students?* A mathematics curriculum that best fosters these areas of learning would likely be the most

successful at preparing our students for 21st-century learning. The various instructional approaches discussed in this literature review all have their strengths and weaknesses. Because of this, a combination approach of inquiry and direct instruction while focusing on the development of critical thinking skills, engagement, and long-term retention should be the basis of any mathematics curriculum. The following chapter is a discussion of the methodology of the project. It will outline the 12 day lesson project including the project format and rationale.

CHAPTER THREE

Project Description

In this chapter, I outline the 12-day lesson division curriculum following the math workshop model that I developed based on my research in Chapter Two. Throughout my teaching experience, I have seen a variety of instructional strategies. I wanted to find which instructional strategies work best for the students to help me to become a better teacher. In Chapter One, I summarized my own experiences of teaching and the struggle to help students develop the skills needed, but also be able to retain information into 5th grade. This led me to my research question: *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st century?* I knew that I needed to research the best practices to develop the kind of learners that are prepared for the future.

In Chapter Two, I researched how to best develop critical thinking skills in 4th-graders. I explored ways to ignite deeper thinking in a classroom through problem solving. The research showed that inquiry instruction is a very important part of developing critical thinking skills. It also showed the importance of directional instruction for some students, like those with learning disabilities, since they may lack the background knowledge needed to assess the topic. In the next part of Chapter Two, I researched how to engage learners in the classroom. Creating a classroom environment that students want to be a part of is important to get students engaged in learning. Again, research pointed to inquiry learning and allowing students to explore topics, collaborate with others, and connect to student's interest. Direct instruction, however, can be engaging if it is done in a way that proves curiosity in the classroom. The final part of

Chapter Two was about retention. In this section, I covered how the brain works and why we remember some things and forget others. When creating lessons one must be mindful of the kind of skill being taught and the goal of the lesson. If the goal is to remember the procedure, then the best instructional practice is through inquiry whereas the best instructional approach for learning a procedure is through direct instruction (Hoffer, 2012).

Chapter Three is an overview of the curriculum that I created. The reasoning behind my chosen instructional decisions is discussed. It also contains the math workshop model that is the framework for the curriculum. I give an overview of the 12-day curriculum and how learning will be assessed. After this I describe the setting and audience for my project. Finally, I conclude with a timeline for completing my project.

Research Framework

When I set off to research my topic, I decided to focus on ways to support learners that would best prepare them for the 21st century. The three main areas of my research were critical thinking, engagement, and retention in mathematics. I have always had a passion for teaching mathematics and I saw a need to develop a stronger curriculum to support my learners in these areas. One area, in particular, that is hard for 4th-graders is division. I felt division would be a good place to harness my energy, but in reality, these skills can be transferred to any subject. Our typical math lesson is 60 minutes long and we follow the math workshop model (Hoffer, 2012). During this 60 minutes, we do an opener, mini-lesson, and have work time and reflection. The lesson plans can be used in their entirety or broken into smaller parts to accommodate different teaching objectives.

All of the concepts I discovered in my literature review were formatted and incorporated into lessons using the curriculum framework of the math workshop model.

Project Format

In my district, we follow a workshop model framework for all areas of study. In the past 5 years, they have adopted a math workshop model. This model is new to many teachers and is still in the beginning stages of implementation. The basic idea behind a math workshop model is to shift students from being empty vessels where teachers fill them with knowledge to teachers and students working together to understand concepts. A well-designed workshop should engage learners, foster active thinking and provide an opportunity for students to work together. Data shows that teachers that use the workshop model not only have more engaged learners, they also make significant gains from standardized measures of achievement (Hoffer, 2012, p. 14). A workshop model has four parts that the student engages in each day: the opener, the mini lesson, the work time. and sharing and reflecting (Hoffer, 2012).

The openers are designed to get students excited and engaged in mathematics. The openers come in a variety of formats, but the ultimate goal is to get students thinking and talking about math. Students start the class with independent tasks that lead to rich classroom discussion. During this time teachers facilitate questions and help students build upon ideas. Meanwhile, students are sharing their thinking and listening to others share out (Hoffer, 2012, pp. 7-16).

The mini-lesson is an opportunity to set the stage for the learning students will be focusing on. It is a chance for teachers to introduce strategies, work through a problem together or to demonstrate how to talk and write about their thinking. This is where direct

instruction will occur. Teachers dominate a majority of the talk time, and students will be listening more (Hoffer, 2012).

The next part of the lesson is the work time. The work time is a great opportunity for teachers to provide some differentiated work. The goal is to provide students with meaningful activities that foster engagement. This may be a single problem that students work on with their peers, or maybe it is a series of problems they work through. This is the chance for students to work together and to collaborate on their ideas. It is also where students learn to talk about math and to explain their thinking. During this time teachers may pull small groups, or converse with a student one-on-one. The mini-lesson is an opportunity for an inquiry approach to learning (Hoffer, 2012, pp. 7-16).

The final part is the sharing and reflection. As a teacher, I find that this is the hardest part to include every day. It is so hard to cut the students off from deep conversation and learning; however, it is important. This part of the lesson gives students a purpose and a voice in the classroom. They get to share their thinking, ask for help, and it helps build a community of learners. Two misconceptions in my understanding that I found were that teachers and students have an equal part in the conversation and that it can be done both orally and in writing (Hoffer, 2012).

The math workshop model is designed to get students in the trenches of learning. To learn, they must do it, but they also need guidance along the way. Providing small bits of direct instruction, to support the background necessary to get to the crux of a problem. Then lots of time should be provided to collaborate and explore interesting, thought-provoking questions. My goal is to develop critical thinkers that are engaged in

their learning and retain what they learn. The workshop model provides the framework for successful instruction.

Project Description

The project is a 12-day curriculum designed to solidify 4th-grader's understanding of division. The division unit is 5 weeks long, so this curriculum will be targeting the last part of the unit. The first part of the unit is targeting an understanding of what division is, and introducing basic concepts of division. I focused on the 4th grade standard of being able to solve division problems in more than one way. All lessons are created in Google Slides for easy access for all. Since students will already be introduced to the concept of division, this part of the curriculum focuses on developing critical thinking skills, engagement and retention.

The 12-day openers are a mix of concepts, both algebra concepts and multiplication are covered. Since spiral learning promotes long-term retention, it is important to give students a chance to revisit previous concepts. The openers are fun, engaging, and a chance to review familiar concepts.

The mini-lessons are designed to go over the main division strategies. I created mini-lessons that are colorful, interesting to look at, and tied to students' interests. There are six strategies that are used throughout the division unit; "Multiplication Menus", "Area Model", "Reverse Big 7", "The Big 7" and "Standard Algorithm." On the MCA test 4th graders may have problems as large as a 3 digit dividend by a 2 digit divisor; therefore, all the lessons build up to working with numbers that large. My research suggests the importance of giving students a chance to complete practice problems to

build retention, so the mini-lesson provides practice problems that can be used to model the process or to practice independently.

The work time part of the lesson is a chance for students to build fluency of skills through practice and inquiry of topics. The lessons are thought-provoking questions that may take the entire class period to solve. Using problem solving in the classroom fosters critical thinking skills. Also, using inquiry in the classroom promotes engagement among students. Chapter Two research data shows the importance of discussion and collaboration among students. The lessons also are designed for students to connect to them, some have a global theme, and others are centered around 10-year-old interests. The goal of the section is to acquire curiosity to foster critical thinking and engagement. Throughout the lessons, students become more familiar with the division process and are in return building fluency and understanding.

The last part of the lesson is the reflection and sharing. Like the openers, this part will look different depending on the goal of the lesson. Sometimes the students share with a partner, sometimes students share with the class, and other times they share their learning through writing or in the form of an exit ticket. My research showed that students need to be able to make connections through the learning process, so finding ways for them to connect to what we are doing in class and know there is a reason for it will prove to help with student engagement and retention. The purpose of this is to gather information, share, and provide purpose for the students' work.

My research in Chapter Two stressed the importance of including both inquiry instruction and direct instruction, so I have incorporated both in my math workshop

model. I was also mindful to create lessons that foster critical thinking skills, are engaging and conducive to building retention based on brain research.

Assessment

Throughout the unit, students are assessed both formatively and summatively. Most of the assessments are done formatively through student observation and discussion. During the lesson, I will be mindful of what is going well and what needs to be adjusted. Students will communicate with me how the lesson is going by reading their body language and listening to their discussions. A summative district assessment will be given at the end of the unit and again a month later to assess students' retention. This data can be used to reflect on how well students retained their understanding of division.

Setting and Audience

The curriculum is designed for a 4th grade classroom at Diamond Path Elementary in District 196. Diamond Path is located in the suburbs of Minnesota's Twin Cities as part of the large school district, Independent School District 196 Rosemount-Apple Valley- Eagan. The district has 19 elementary schools. Parents can choose to send their child to the local elementary school or to one of the magnet schools. We also now offer an online school. Diamond Path is a diverse school that attracts families due to being a magnet school of international studies. Our focus is providing students with a well-rounded education through a global lens. Global themes are interwoven into our curriculum and students receive 90 minutes of language each week.

According to the Minnesota Department of Education, the 2021 enrollment data at Diamond Path has 715 students enrolled. Of the students enrolled, 58.3% are White, 10.8% are Asian, 10.5% are Hispanic or Latino, 9.9% are Black or African-America,

9.7% are two or more races and .8% are American Indian or Alaska Native. The school is considered a low poverty school with 12.6% of students receiving free or reduced lunch. The school provides English language services for the 9.9% of English learner students; as well as, providing special education services for the 12% of students that qualify for services.

As I have discussed earlier, this curriculum will be designed for 4th grade students at Diamond Path. It may also be offered to other 4th grade teachers in the district through my work with curriculum development. Diamond Path has four sections of 4th grade. Classroom sizes range between 24-29 students. They are between the ages of 9 and 10. They range in mathematical abilities, gifted and talented students, special education students, English language learners, and regular education students are mixed together. Even though my audience is geared towards 4th grade students, the strategies and concepts can be incorporated into any classroom by teachers who are looking to improve critical thinking, engagement and retention.

Timeline

January 2021	Research for my capstone began
March to August	Create, review and edit of capstone
June	Work to design the lessons
July	Create and edit ten lessons that increase students critical thinking skills, engagement and retention.

August	Capstone Presentation and submission of final work.
January 2022	The lessons are intended for use in the Second semester of the upcoming school year.

Summary

In this chapter, I have described my project and how it relates to my research question, *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th grade students for the 21st century?* I have outlined the frameworks and the lessons created for my project on the previously listed professionals in my research paper. I have also discussed the setting and audience this project is intended for and my timeline for implementing it. I plan to complete the capstone project as of August of 2021. In the next chapter, I will reflect back on my capstone experience and make any adjustments for future research projects in this field.

CHAPTER FOUR

Conclusion

Overview

As a teacher, I have seen the struggle students have with connecting to mathematical concepts. In my experience, students were going through lessons, but not engaging in math thinking that would result in long term retention or critical thinking. In the current culture of education, the emphasis is on performing well on state assessments and not developing mathematical thinkers. The purpose of this capstone was to explore best practices that could be applied to the classroom that would foster deep thinking and engagement, and that, in return, would result in understanding for students that would be standards driven. The research question was: *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st century?*

In this chapter, I reflect on the process of creating a 12-day lesson plan that was grounded in the best practices found throughout the research process. I have made connections between what was created and the literature that supported it. I then discuss the ways in which I plan to share my project with other educators.

Reflection of the Capstone Process

The capstone project was a challenging, yet rewarding, experience for me. I have never been a writer; in fact, writing is very challenging for me. When I decided to pursue my Masters program I acknowledged that I would need a lot of support systems in place

to complete the process successfully. I was fortunate enough to have a family and colleagues supporting me along the way. I used them to reflect on ideas, to help overview my writing, and to provide words of encouragement.

Now that the process is over, I can look back at what I created with great pride. I have long wanted to better myself as an educator and create lessons that would help my students explore division in a deeper way. The project not only provided me with the opportunity to learn best practices, it allowed me time to create lessons from which I felt my students could benefit. I am excited to share what I created and continue to implement what I learned during future math modules.

When I started this process I really enjoyed learning about the best practices. It had been a long time since I had read an education journal or a professional development book. I found myself talking to colleagues about current authors and best practices. It was liberating to think about teaching again in a way that I have not done in many years. I subscripted to NCTM and actually read articles from the monthly magazine that arrived. I enjoyed having conversations with other teachers about how to better our practice and started to look differently at what we had as a curriculum.

The most challenging part of the capstone for me was the literature review. Taking all of my ideas and organizing them into a specific revelation was hard. I found myself rambling through various ideas and then going back and editing toward specificity over and over. It was not the way I was taught to be a writer, nor was it the way I taught writing. Throughout this process I thought about my own students and the skills I have taught them throughout their learning. I realized that there are many ways to think, write, and research. Just like math, there is not one right way to do things. I found myself

suggesting ways to go through the writing process instead of acting as if there was one correct way to do it.

Shortly after starting my capstone process I was asked to join our district team to help write a new curriculum that would serve students and teachers better during the pandemic. It was a great opportunity for me to try out what I was learning in my professional reading and share it with other teachers. I was able to get feedback from teachers about what lessons were engaging and what lessons were not. I found myself changing the way I created lessons, and trying new ways to make them engaging. As a creator, I noticed that creating critical thinking lessons took time and effort. It was much easier to create a lesson that was a series of problems than to create a problem-based learning activity.

At the end of the school year, I started my capstone project and was able to reflect on areas that needed improvement and could focus on creating one module. Division is a new standard for fourth graders; the original module was focused on providing practice with “naked numbers.” I wanted to take the division module and add critical thinking lessons that would be intellectually engaging.

The capstone project has taught me a lot about myself as a learner and educator. I have always preached the importance of being a lifelong learner, but realized that I had become an ideal learner. I was only learning what was set in front of me during professional development and not seeking my own learning. I am very fortunate to have had the opportunity to reunite with my love for learning. I am thankful for the professionals around me who challenged me to think differently and to share their

knowledge of math with me. This process would have been much harder without them, so I thank those who supported, encouraged and challenged me to be a better educator.

Literature Review Connections

Throughout my literature review I had no problems finding information about critical thinking and engagement. A quick Google search proved that finding ways to get students involved and thinking during a lesson was something teachers were struggling with. Teachers have a challenging job in the sense that they must deliver information in a way that students can understand. Freire theorized that students are not empty vessels taking in information, but instead that they must be involved in the learning process to gain new knowledge. To involve the students in the learning process, they must be engaged (as cited in Behizadeh, 2014).

One of the leading researchers in this area is Jo Boaler. Boaler's research supports the idea that students learn best when they engage in deep thinking activities with others. It also supports the idea that math should be inquiry based. Through discovery, students build confidence in their ability to solve problems, and hence, they are more likely to be successful. Students need opportunities to see the "beauty in mathematics" (Boaler, 2016; Gasser 2011; Rhodes 2020). Studies show that students will not retain information if they do not connect to the topic (Barnes, 2006; Gilbertson, 2017). Therefore, when I was creating lessons, I tried to make the lessons engaging by using topics they could relate to. Another important aspect for engaging students is to foster collaboration. There is power in working together with others and knowing one are not alone with one's struggles (Hoffer, 2012).

Finding information that supports the best way to retain information was more challenging. The reason is because learning is a complex process. Our brains retain information differently depending on how the information is presented. According to the Knowledge-Learning-Instructional Framework (KLI), deciding on which instructional method to use should be based upon what the teacher's learning objectives are for that specific lesson (Yeo & Fazio, 2018). A balanced approach to instruction is the best outcome for students if they are to retain information for analysis and insight into complex concepts. There are benefits for students working with problems through inquiry instruction, and there are also benefits for teachers in using a more direct instructional approach. Therefore, when creating my lessons, I provided lessons that were both inquiry based, and moments that allowed for direct instruction.

Implications

These lessons were designed for a fourth grade classroom; however, all teachers could use strategies that foster critical thinking skills, engagement, and long-term retention regardless of the subject matter. Varied strategies could be used with the upper elementary levels due to the maturity level of the students and their being able to handle more independence. I have observed that incorporating movement and collaboration could be more challenging for the younger grade levels.

Critical thinking activities could look different at different grade levels. At fourth grade, most students are capable of reading a story problem and working through it. At lower grade levels, additional support would be needed. The same would be true for instructional approaches. At lower grade levels, more inquiry-based activities could be

incorporated pertinent to the outcome of wanting students to be able to successfully understand procedures such as addition and subtraction.

Limitations

When thinking about limitations a few things have come to mind, the first of which is the familiarity with the Google programs. Since all of the lessons are currently designed with that format, some teachers may not be used to it and find it hard to access. Most teachers tend to stick with programs they are familiar with. Another limitation might be technology. Since a majority of the lessons are through a digital platform, if someone does not have a strong Internet connection, accessing the lessons could be challenging. Every district is different, and access to fast Internet service could be a limiting factor.

Baring in mind that some students may still be doing online learning, I created mini- lessons that provided audio. This allows all students to access the information. Other parts of the lesson may be more challenging without it. The independent learning part would be best if printed out, and some are designed with collaboration in mind. This could be a limitation for schools that do not have the ability to get print material to students nor do they have the ability to provide collaboration opportunities in a digital format.

The last limitation is the acknowledgement of my own personal bias. I created these lessons with my own students in mind. Other teachers may have students with different interests or abilities. I am also a white teacher creating lessons through my own lens. I am aware that personal bias may be subconsciously incorporated into my lessons. Other teachers using these resources should note their own personal biases.

Suggestions for Ongoing Research

During the research process I found that critical thinking and engagement has been well researched. I also found that it has changed over time. As educators, we are constantly revisiting ways to get students to think and engage with the material. As the world around us changes, so is the need to change the way we teach. Students today are different than students 10 years ago and will be different from students 10 years in the future. Due to the ever changing world, a continual need for research is needed.

I found research on retention polarizing. It seems that people that believe in inquiry-based learning believe that it is the best way to teach. The same is true for educators who believe a direct approach to teaching is better for students. I found that, based on the way the brain develops, a balanced approach is better for students. Throughout my research, I found it challenging to prioritize certain best practices and believe that more research should be done in regards to retention of information.

Sharing My Project

As stated earlier, I am on the district team to write and share our curriculum. First, I will share it with the other fourth grade teachers in my building along with our math coach. After I share my 12 days of lessons with my team, I will begin sharing them throughout the district. Once the unit is complete, I will use the feedback from other fourth grade teachers across the district to modify and adjust my lessons. I will also be uploading my capstone project to Hamline University's Digital Commons. From there, it will be available to anyone that is interested in my question: *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st century?*

Summary

My entire capstone project was based on the question I had about best instructional approaches. My research question was, *Which instructional approach best fosters critical thinking skills, engagement, and long-term retention in mathematics to best prepare 4th-grade students for the 21st century?* I developed this question while being a fourth grade teacher. I felt there was a lack of connection among math concepts implemented by teachers, and students were not retaining information the way I hoped. I sought to research best practices to be able to use them in my classroom in an effort to develop a 12-day lesson plan during the division unit. I used my research to guide my lesson creation, keeping in mind that a balanced approach of instruction is best for students. I also tried to create lessons that were engaging and helped students develop critical thinking by using the strategies I found during the literature review.

In conclusion, this was a great experience for me because I believe it has enabled me to become a better teacher, researcher, and writer. I feel proud walking away from what I created and am confident that my new knowledge will guide me as I move forward in creating lessons. I have learned a lot about critical thinking, engagement, and retention. I am excited to share my new learning with others and hope to remember the power I felt from self-guided professional development. I look forward to teaching division this year and to seeing how my research helps my students.

REFERENCES

Allmond, S. & Fielding-Wells, J. & Makar, K. (2010). Thinking through mathematics: Engaging students with inquiry-based learning - Book 1 (ages 6-8).Education Services Australia.

Barnes, M. K. (2006). How Many Days 'til My Birthday. *Teaching Children Mathematics*, *February*, 290–295.

Bartell, T., Paul, R. W., & Elder, L. (1997). *California teacher preparation for instruction in critical thinking: research findings and policy recommendations*. Commission on Teacher Credentialing, State of California.

Behizadeh, N. (2014). Enacting problem-posing education through project-based learning. *The English Journal*, 1*04*(2), 99-104. Retrieved March 18, 2021, from http://www.jstor.org/stable/24484422

Boaler, J. (2016). *Mathematical mindsets: unleashing students' potential through creative math, inspiring messages, and innovative teaching*. Jossey-Bass & Pfeiffer Imprints.

Defining critical thinking. https://www.criticalthinking.org/pages/defining-critical-thinking/766.

Diego-Mantecon, J. M., Arcera, O., Blanco, T. F., & Lavicza, Z. (2018). An engineering technology problem-solving approach for modifying student mathematics-related beliefs: Building a robot to solve a rubik's cube. *International Journal of Technology in Mathematics Education*, *26*(2). https://doi.org/10.1564/tme_v26.2.02

Eckenrode, C. W. (2016). *Teaching Problem Solving In Mathematics: Cognitively Guided Instruction In Kindergarten* (thesis). Digital Commons@Hamline. 4177. https://digitalcommons.hamline.edu/hse_all/4177

Elfstrom, D. (2018). *The relationship Between The Development Of Math Operation Proficiency And Student Confidence* (thesis). Digital Commons@Hamline. 4430 https://digitalcommons.hamline.edu/hse_all/4430

Gasser, K. (2011). Five ideas for 21st century math classrooms. *American Secondary Education,39*(3), 108-116. Retrieved from www.jstor.org/stable/23100426

Gilbertson, N. J. (2021). The opportunities of no-solution problems. *Mathematics Teacher: Learning and Teaching PK-12*, *114*(3), 205–211. https://doi.org/10.5951/mtlt.2020.0146

Hoffer, W. W. (2012). *Minds on mathematics: Using math workshop to develop deep understanding in grades 4-8*. Heinemann.

Jensen, E. (2000) *Moving with the Brain in Mind.* Educational Leadership November, Vol. 58, No.3, Pgs. 34-38, ASCD. https://www.nemours.org/content/dam/nemours/www/filebox/service/preventive/nhps/pep/braininmind.pdf

Johanning, D., Weber, W. B., Heidt, C., Pearce, M., & Horner, K. (2009). Links to literature: The Polar express to Early algebraic thinking. *Teaching Children Mathematics*, *16*(5), 300–307. https://doi.org/10.5951/tcm.16.5.0300

MacKenzie, T. (2016, December 1). *Bringing Inquiry-Based Learning Into Your Class*. Edutopia.https://www.edutopia.org/article/bringing-inquiry-based-learning-into-your-class-trevor-mackenzie.

Magaletto, R. (2021). Engaging students through modeling. *Mathematics Teacher: Learning and Teaching PK-12*, *114*(2), 125–131. https://doi.org/10.5951/mtlt.2020.0025

Meadows, M., & Caniglia, J. (2021). Incorporating Popular Media to Engage Students. *Mathematics Teacher: Learning and Teaching PK-12*, *114*(3), 174–186. https://doi.org/10.5951/mtlt.2020.0225

Mishra, S., & Iyer, S.(2015) *An exploration of problem posing-based activities as an assessment tool and as an instructional strategy*. *RPTEL* 10, 5 . https://doi.org/10.1007/s41039-015-0006-0

National Council of Teachers of Mathematics(NCTM). *Principles and Standards for School Mathematics.* Reston, VA, 2000.

National Governors Association Center for Best Practices (NGA Center) and council of Chief State School Officers (CCSSO). 2010. Common Core State Standards for Mathematics. Washington, D.C: NGA Center and CCSSO. http://www.corestandards.org

Nugent, C. M. (2006). How many blades of grass are on a football field. *Teaching Children Mathematics*, *February*, 282–288.

Odegaard, K. J.(2015), *Using Graphic Organizers, Cooperative Learning, and Written Reflection to Improve Mathematics Problem Solving Skills* (Publication NO. 175) [*Master's Capstone Theses, Hamline University*] Digital Commons@hamline. https://digitalcommons.hamline.edu/hse_all/175

Perkins, D. N. (1995). *Smart schools: better thinking and learning for every child*. Free Press.

Pink, D. H. (2006). *A whole new mind: how to thrive in the new conceptual age*. Cyan.

Rhodes, S. (2020). Eliciting critical thinking through purposeful questioning. *Mathematics Teacher: Learning and Teaching PK-12*, *113*(11), e71–e77. https://doi.org/10.5951/mtlt.2019.0089

Ritchhart, R., Church, M., Morrison, K., & Perkins, D. N. (2011). In *Making thinking visible how to promote engagement, understanding, and independence for all learners* (pp. 3–39). Jossey-Bass.

Rooney, C. (2012). *How am I using inquiry-based learning to improve my practice and to encourage higher order thinking among my students of mathematics?* (thesis). Educational Journal of Living Theories.

Spitzer, M. (2006). Brain Research and Learning over the Life Cycle. *Personalising Education*, 47–61. https://doi.org/10.1787/9789264036604-4-en

Swanson, H. L., Lussier, C. M., & Orosco, M. J. (2013). Cognitive Strategies, Working Memory, and Growth in Word Problem Solving in Children With Math Difficulties. *Journal of Learning Disabilities*, *48*(4), 339–358. https://doi.org/10.1177/0022219413498771

Thomas, J. W. (2000, March). Review of *A Review of Research on Project-Based Learning*. *The Autodesk Foundation*.

What is CMP. Site Name. (0AD). https://connectedmath.msu.edu/.

Wiemken, R., Sri Padmi, R., & Matney, G. (2021). Global connections through mathematical problem solving. *Mathematics Teacher: Learning and Teaching PK-12*, *114*(3), 219–226. https://doi.org/10.5951/mtlt.2020.0097

Wu, S.-C., & Lin, F.-L. (2016). Inquiry-based mathematics curriculum design for young children-teaching experiment and reflection. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(4), 844–860. https://doi.org/10.12973/eurasia.2016.1233a

Yeo, D. J., & Fazio, L. K. (2018). Supplemental Material for The Optimal Learning Strategy Depends on Learning Goals and Processes: Retrieval Practice Versus Worked Examples.

Journal of Educational Psychology, *111*(1), 73–90.

https://doi.org/10.1037/edu0000268.supp