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Teaching New Generations the Language of Mathematics

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Teaching New Generations the Language of Mathematics

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ABSTRACT

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By Nicholas Kolta

In the beginning of the school year, many 9th grade students dread having to walk into a mathematics classroom and try to understand all those incomprehensible symbols. This action research is an attempt to delve into how we can make mathematical language more relevant, meaningful, and valuable in our students' lives. The research shows that reasoning and understanding is equally important as procedural skills. In fact, giving students time to explore and make sense of mathematical language and its' purposes is necessary to engage in math fluency skills in meaningful, informed, and flexible ways. The research also demonstrates that to give students the resources they need to explore and interact productively with mathematical language, teachers need to frequently provide contextual examples that students can understand and relate to. Additionally, teachers need to carefully design materials and activities that will help reduce students' cognitive load and help students organize everything they are learning in meaningful ways.

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CHAPTER 1

INTRODUCTION

Teaching means leading the next generation to be able to reason, solve problems, and communicate with one another in building a better and more prosperous future. Through unity we join hands, through creativity we see imaginative possibilities, and through dedication and open-mindedness we nurture these talents and turn rocky unsafe paths into paved roads, giant moving metal monsters that help plow our fields and make transportation easy, stores that collect this abundance of food and other goods all in one place, large metal boxes that cool this new wealth of food, and penicillin and other drugs to help treat infections and illnesses. Humans often struggle to accept the unknown and are often fearful of it, but the best leaders dedicate their lives to spreading their passion and showing other people bright unimaginable possibilities. Even when everyone laughs at them and declares they are insane, leaders continue to ignite a flame within other's hearts and to inspire within others the same passion that has driven humanity to this era of opulence to begin with.

Mathematics was always meant to be a tool of innovation, thinking outside the box, and reasoning in new ways. Teachers need to inspire and show students just how powerful math is. Math has already achieved unimaginable feats and will continue to do so. People once laughed at the then-absurd notion of creating an inorganic means of transportation. Many people felt it was unnecessary and even silly to create a carriage that moved independently. Why create such a strange metal beast when horses got us around just fine? Most of these same people overlooked that horses were once thought of the same way. Why ride such an unpredictable and scary beast when my legs will take me there just fine? In the past, fear of the unknown has even caused some

brilliant inventers to be regarded as deranged and dangerous. Who in their right mind would believe that there are invisible creatures that make us sick? What motive did these people have that confused and scared their fellow citizens and insisted that soap and disinfectant would help create better surgical outcomes and keep people clean and safe? Well, as crazy as it may have seemed at the time, these people were right. Bacteria, viruses, and parasites all do exist and using products like soap do help us stay clean and safe.

The invention of schools gave society a lot of potential that is still untapped and ripe for the taking. Teachers especially have a unique opportunity to open people's minds and show students why it is important to reason and think in new ways and to be open in collaborating with our fellow humans in designing products that will improve our lives, potentially save our planet, and perhaps even take us beyond our solar system. To do this, however, teachers need to instruct our students how to think like mathematicians, scientists, and other creative engineers of positive change. Students need to understand the symbolic mathematical language and need to be able to evaluate and analyze tables, charts, and graphs of real-life data and explain why that data is important, and how it might be used and repurposed in new and valuable ways. Time is the most precious commodity that we have, and it is a teacher's responsibility to ensure that that time is being well invested in aiding students in gaining essential skills that will support them for the rest of their lives!

Modeling Reasoning

Mathematics is a language that many people in our society have little to no idea how to speak, think, or reason with. Even among mathematicians there are varying dialects and preferences in how we approach mathematical procedures and reasoning. Therefore, using

modelling and think alouds is essential for showing students how to translate between normal English and symbolic mathematical language, tables, and graphs. Most importantly, I need to model why I am choosing to speak, write, and think the way I do. Many teachers focus too much on showing students how to solve mathematical problems without providing a context and explanation for why we use mathematical models. This leads students to blindly mimic and generalize mathematics in inaccurate ways. Therefore, providing them with a specific and relatable context for reasoning through symbolic and graphic representations is fundamental towards building genuine understanding and interactions with the content. Teaching students to reason is a necessary first step for connecting society to a better understanding of how and why mathematicians think and apply our skills.

Teaching

Teachers can only guide the learning process if they build an open-minded and understanding community within their classroom. A classroom cannot be a place of dictatorship, but instead needs to provide a cooperative and engaging atmosphere where students can explore and make meaning as they interact with new material and reconceptualize the way they look at the world. While teachers do provide modeling, structure, support, and feedback, students also need to feel comfortable with taking on leadership roles, expressing their thoughts and conclusions, and teaching their peers as they themselves increasingly reach a greater mastery of the material. Teachers must also always be aware of gaps in understanding and misconceptions, but this knowledge must be carefully utilized and reflected upon. If students perceive their pursuit of mathematics as an extremely dangerous and fruitless undertaking, they will not consider the investment worth the risk. Therefore, teachers need to consistently provide feedback

that acknowledges growth and cleverly design activities that gradually help students fill in gaps in understanding and rethink and rebuild new neurological networks that help guide their understanding of algebraic language and other mathematical representations. Guiding students to build confidence in their ability to learn and grow is a fundamental necessity towards building a healthy and cooperative classroom.

To build a classroom that acknowledges student's strengths and builds upon their pre-existing knowledge, teachers need to be flexible in how they guide their instruction. Instead of teaching students to merely memorize a bunch of abstract mathematical procedures, teachers need to show students the reasoning behind those concepts and help organize notetaking strategies that will aid students in connecting and accurately identifying flexible ways of thinking and solving complex problems. Furthermore, teachers need to provide activities that relate mathematics to real-life situations that students can easily connect to and understand. Mathematics should be connected to activities such as sports, sewing, cooking, investing, and other useful skills that are essential to students living balanced and healthy lives. Embedding mathematics into students' already existing identities will help students buy into the subject. Giving students familiar contexts to connect to will also reinforce the bridge between the school and the community. Mathematics cannot just be another subject students learn to graduate but should instead be a language students can use to connect to, expand upon, and express their strengths.

Student Collaboration

Vygotsky and other bright psychologists and scientists have recognized the importance of working together to achieve something that we never could achieve just by ourselves. When scaffolding and structuring challenges, students need to be grouped so that they can complement

each other's strengths and pool their understanding together to achieve success and a sense of unity. People with similar beliefs and characteristics often group together, but while emphasizing our similarities can help us unite, repeatedly forming homogenous groups can also isolate us from people with strengths that help us grow and think in new ways. For hundreds of years blacksmiths, carpenters, farmers, and other people relied on each other's varying strengths to ensure everyone had enough food, warm clothing, shelter, and other necessities. Teachers need to bring awareness to the need to collaborate and interact with people with varying strengths, beliefs, and values. By organizing heterogenous groups, students can learn that our differences help promote success just as much as our similarities.

Heterogenous grouping can also allow students to rethink their views of the world and explore in new ways. Mathematics influences every aspect of our lives including making buildings, bridges, cars, trains, airplanes, appliances, tractors, fertilizer, food, clothing, medications, surgical procedures, wise and balanced investments, organized and successful businesses, and countless other organized and creative ways of thinking that helps make our society prosperous. Therefore, it goes to reason that people from varying backgrounds and skillsets can all contribute to building a healthy and wealthy society in which everyone is a respected citizen with a meaningful purpose. Human history has shown us that Egyptians, Greeks, Native Americans, and numerous other populations have all made valuable contributions to the fields of mathematics and science. Teachers need to spread awareness that math, innovation, and prosperity is within everyone's reach. Through flexible thinking, exploration, and perseverance Garrett Morgan, Madame Curie, and countless other inventors have solved mind-bogglingly complex problems. The way we think about and use mathematics is only limited by our collective imaginations. Teachers need to show students the importance of

embracing a variety of wisdom, interacting and collaborating with people from other cultures, and reasoning in different ways.

Assessment

Many 9th grade students come into high school already believing they are not good at math and believing they will struggle. Students' lagging performance on state summative assessments reinforces the beliefs and stereotypes within our schools that some people just aren't "good" at math. The National Center for Education Statistics (2019) shows that many students, especially racially diverse students, do struggle greatly in standardized math assessments. In 8th grade, only 14% of Black students, 15% of American Indian/Alaska Native, 20% of Hispanic, and 21% of Pacific Islanders score at or above proficiency level in mathematics. Even among students that identify as two or more races and White, only 38% and 44% respectively score at or above proficiency level. The education system has reinforced this message of inevitable failure in mathematics for far too long. Teachers need to actively design lesson plans that emphasize student growth and successes. Assessments should also be flexible and positive to help promote and emphasize student growth and success.

Well-designed formative assessments play a critical role of helping inform teachers of how students are reasoning and why they are arriving at their conclusions. Using frequent formative assessments helps guide the direction teachers take with reviewing old material and introducing new material. These formative assessments can include quick surveys, having students hold up one to five fingers to express comfort on a topic, math activities and projects, having students share written reflections or verbal reasoning, and any other number of ways teachers can receive feedback that informs them where students are in their thinking and

reasoning. By gaining awareness of student thinking, teachers can make far better choices on what activities and supports will help students gain new fundamental skills, fill in gaps in understanding, and reduce confusion and misconceptions that make mathematics so difficult for so many of our students. Understanding why and how students are thinking is fundamental in reshaping the way they approach and think about mathematics and other subjects.

Thoughtful formative assessment feedback also helps students gain a positive mindset and guide their own learning. By providing personalized feedback that acknowledges and emphasizes students' growth, teachers can show students that their effort is making a genuine difference. Furthermore, as students regularly experience successes and learn to think and reason increasingly flexibly and in new ways, students can feel increasingly comfortable with the foreign mathematics language and feel their investments are well-worth the time and energy they put into understanding the content. Thoughtful and intentional feedback and activities also show students that the teacher cares about their success and will invest just as much in their success as they invest themselves. Building a caring and thoughtful atmosphere requires that teachers and students are both actively engaged in reflecting and guiding the teaching and learning in a classroom.

Summative assessments can serve as the ultimate symbol of success and growth. At the end of a unit, when teachers have ensured that their students have mastered the material, students can see for themselves how much they have grown, as they tackle a satisfying challenge that proves their new intellectual prowess and reasoning. As students surprise themselves at how much more they understand, students will finally realize that math isn't just for "smart" kids, but is instead just a matter of effort, time, and exploration. Math is like learning any other skill whether it is walking, a sport, an instrument, how to cook, or any number of other skills. As

students learn to identify with being mathematical thinkers and reasoners, they can then spread their awareness to their siblings, friends, family members, and community. Once mathematics becomes widespread and less feared, then increased positive thinking and intentional voluntary practice will lead to increased math proficiency in our society as a whole! No longer will math be an avoided and forbidden topic, but instead will be embraced just like a fun sport or a worthwhile activity that can help spread prosperity and innovation throughout our society!

Teachers should always reflect on backwards design as they structure, design, and guide their course. Backwards design is a strategy in which the teacher focuses on crafting assessments to meet large essential goals first and only then on planning the activities and smaller assessments that will help students get to those goals in a carefully designed step-by-step process. In doing so, the instructor makes an entire course or unit more intentional, and students are given a clear understanding of the expectations in a unit or course and the path of learning that will enable them to achieve those expectations. By focusing on the large reasoning skills as provided in the guidance of state standards, teachers can then design activities that focus on essential skills students will need before they can tackle more complex reasoning challenges. Then by intentionally designing activities that build upon fundamental reasoning skills, teachers can be equally purposeful as they look for evidence of understanding. This evidence can then guide teachers towards deliberate instruction that fills in student gaps in understanding and helps reduce misconceptions and reshapes the way students think and explore. As students increasingly build foundational knowledge and the ability to understand and analyze mathematical symbolic and graphic language, teachers can then interweave these skills together and connect smaller scale skills and reasoning to the larger end-game reasoning goals. Teachers need to always be aware of the long-term goals in order to intentionally weave a multitude of other mathematical

skills together. Teachers need to use backwards design o enhance their own awareness of the nature of the puzzle pieces their students will need to conquer complex reasoning goals.

Summary

Mathematics is a content area that students and society at large currently struggles greatly with. To encourage a growth mindset in my classroom, I need to provide an organized structure to guide my students thinking, heterogenous groups of students that can reinforce and expand upon each other's thinking, positive and personalized feedback for all my students, and intentional activities that allow my students to explore and connect knowledge and skills that are essential for them to be able to tackle even larger challenges. Additionally, above all else I need to teach my students how to reason mathematically. A fundamental structure of thinking and reasoning is essential to making exploration and group interactions productive and meaningful. Therefore, I need to provide frequent modeling and deliberately think aloud so that students can get used to what it means to reason like a mathematician and how and why mathematicians reason through and find solutions to real-life problems. Procedures are meaningless without demonstrating the reasoning behind each step. Providing genuine meaning and authentic activities is essential towards guiding my students towards a better understanding and awareness of what it means to be a mathematician.

InTASC Learner Standards

My teaching philosophy aligns with the Interstate New Teachers Assessment and Support Consortium (InTASC) core teaching Standards. I recognize that all students need to feel their interests and values are being represented in their learning. To help students feel that

mathematics is relevant in their development, my math class will examine a wide variety of mathematical relationships including activities such as cooking, sports, and investing. In addition to providing a positive and motivating classroom environment that supports my students' emotional well-being and respects students with varying hobbies and interests, I will also provide challenging activities for each student. I acknowledge that students vary in their understanding of operations, fractions, word problems, and algebraic language. I also understand that students come from a wide variety of socioeconomic standings, diverse cultures, and I interact every day with numerous students that speak Spanish at home. While I sadly am not fluent in Spanish or any language besides English, I plan to do everything in my power to make sure that everyone feels welcome in my classroom, receives appropriate challenges, and feels respected and valued by their peers.

The United States is filled with people with varying viewpoints, interests, traditions, and strengths. Giving students opportunities to understand and appreciate the diversity within my classroom is a skill that will help them the rest of their lives. An inclusive atmosphere in my classroom is non-negotiable, and I will ensure from the very beginning of the year that students understand the benefits of having a collaborative atmosphere in which students can freely share their knowledge and viewpoints. If any student is disrespectful to another person, I will talk with them and make sure they understand why their remark or action was offensive and how they can make more sensitive choices in the future. I have interacted with many students who struggle with conflict management skills and as their teacher, it is my responsibility to teach them how they can be more diplomatic in the future and why this is essential for their own success and prosperity. Facilitating a fair and equitable environment is a vital skill and I plan to role-model and explicitly teach this skill so that my students can become upstanding and independent

conflict resolving citizens and valued future employees, spouses, parents, friends, and any other role they might aspire to be. I also plan on teaching them to analyze data from their community and use that data to make independent decisions that will make their community a better place.

InTASC Content Standards

I understand that mathematics is an essential tool of inquiry. Mathematics describes the people and objects we interact with daily. Mathematics enables us to interpret and evaluate graphs and other symbolic visuals. Mathematics even lets us use a symbolic language that helps us capture the world we live in in a totally new way! To make this often abstract and misunderstood language meaningful for my students, I will translate mathematics into English, and I will use cognates to also assist students with stronger language backgrounds in languages such as Spanish. I will model mathematics thinking out loud and show them the reasoning process in mathematics. I will use meaningful examples such as relating distance walked and time (linear), ice cream sales and temperature (exponential), and height of a basketball as it is passed a certain distance to a nearby player (quadratic). Mathematics is in everything around us including buying two hours of intense action at a movie theater, investing money, amount of profit a business makes in relation to the number of employees they hire, and even the happiness you create when you tell your peer that you are proud of them! While the latter example may not be as easy to measure (how *does* one measure happiness? That is an intriguing question!), I will show my students how mathematics is in many ways equivalent to innovation and prosperity!

InTASC Instructional Practice Standards

In mathematics, an area that so many students in our country struggle in, I understand the need for frequent and flexible assessments. Understanding what is influencing my students reasoning as they interact with mathematical operations, proportions, word problem, graphs, and other forms of mathematical language and visuals is crucial. This understanding will aid me in designing activities and assessments that align with fundamental skills my students need in order to continue being successful in my course. Additionally, in the same way that assessments inform me what my students understand, assessments also guide my students in recognizing their own growth and giving them a clear path forward with future goals I set according to where students are at in their development. Then, with both my students and I on the same page as we progress through our course, I can then design activities that will aid my students in the learning goals they need the most. Providing opportunities to explore key concepts is critical for my students and assessments give me the feedback I need to design assessments that are just right for my students.

Assessments not only instruct me in what mathematical knowledge my students need more time to explore, but they also give me heightened awareness of what my students are interested in. This knowledge is essential in providing engaging opportunities for students to explore topics they care about. Additionally, by applying mathematics to a wide array of fascinating subjects, I reinforce my students' respect for mathematics as an indispensable tool for exploration and prosperity. Furthermore, integrating mathematics with other disciplines will provide my students with vital real-world skills they can use both in their occupation and in their personal lives. Adding yet one more cherry to the benefits of using assessments to inform my

teaching is assessment outcomes will help advise me how to improve my teaching. In mathematics there is a huge variety of helpful instructional strategies I can use including modeling, think-alouds, using concrete manipulatives and other realia, translanguaging, exploratory activities, group co-construction of meaning, independent practice, solved examples, and more. Assessment outcomes will enable me a means to discover how I can best allocate class time to ensure the best possible learning outcomes.

InTASC Professional Responsibility Standards

As human beings we play many complex roles in the lives of all the people around us. At various stages of our lives many of us become an acquaintance, friend, sibling, child, parent, employee, voter, passerby to someone who needs help, and so much more. As a teacher, I need to role-model how to be a good human and to love and appreciate everyone around us. The world will be whatever we make it and during these pandemic times, it is especially important to light a candle of hope and show my students how to live healthy and fulfilling lives. To do so, I will always be developing my conflict resolution skills, the way I phrase questions to help facilitate the learning and exploration process, providing personalized feedback and supports for each of my students, designing a clear path of intellectual and emotional growth for all my students, and creating positive partnerships with parents and other influential figures that play vital roles in helping each student become healthy and independent. As a teacher every positive interaction is an opportunity to build my students' confidence in themselves. Likewise, every communication is an opportunity for me to show my students and their families that even in the midst of a pandemic, I am there to support them, and I care about their futures. My fellow teachers will also be beacons of hope and inspiration and in this way we will help revitalize each other, show our

students they have many people who care about and believe in them, and provide a unified message that together we can accomplish so much. When teachers, parents, and administrators combine our wisdom and kindness and become unified in our goal of helping the next generation achieve success and prosperity, there is absolutely nothing we cannot accomplish!

Conclusion

I believe the goal of a teacher should always be to create a motivating and respectful attitude for their students to grow and learn new things. Ladson-Billings (2017) observed eight outstanding teachers that inspired their Black, Latinx, and other students to use their limited resources, relying mostly on their own strengths and determination, to achieve major improvements in their communities. When students are put in positions of leadership and teachers genuinely care and provide continuous support and encouragement, those students will rise up to make better lives for themselves and for everyone they care about. In this way, teachers combine the strengths of all their students while simultaneously reinforcing everyone's cognitive, emotional, and social development so that all youths can have a purpose, be a valuable element for positive change, and build lifelong skills and memories that will allow them to continue to be leaders of change and advocate for a better more prosperous future. To achieve a motivating and caring atmosphere in my classroom, my upcoming literature review focuses on three questions:

1. How can I inspire students from a wide variety of backgrounds and provide better personalized supports for all the individuals in my classroom?

2. What strategies can I use to emphasize my students' assets so that every student can see that they are valuable, and their contributions are essential for the greater good of the classroom and of society?
3. What strategies and assessments can I use to make the mathematics learning experience smoother and more positive for my students?

CHAPTER 2

LITERATURE REVIEW

Purposes and Objectives for the Literature Review

My purpose in this review of the research was to discover how teachers and researchers have looked at effective teaching and teacher growth in their discipline. I searched for research on culturally responsive pedagogy because many of our growing racially diverse populations don't feel like their culture is being valued in our education system. I also searched for studies relating to creating an atmosphere of acceptance and unity because working with diverse people is an essential skill my students will need when they graduate high school and enter the workforce, military, or college. Additionally, because I would be studying my own practice and focusing on these ideas in my endorsement area, I looked for studies that indicated the kinds of instruction that are effective for making math less intimidating and increasing participation. Many students come into 9th grade algebra believing math is only for smart people and no matter how hard they try they just won't get it. Students will only take on the identity of being a mathematician if they believe it is relevant, valuable, and if growth in mathematical thinking feels viable.

This literature review addresses my knowledge of these concepts as a foundation for my understanding to set goals and grow from in my own teaching. I especially looked for research that described effective strategies for personalizing the learning experience for students from a wide variety of cultures and backgrounds, differentiating instruction in ways that enable me to emphasize all my students' strengths, and making the acquisition of mathematics skills smoother and less intimidating. Application of this research was an essential part in building my own

knowledge base for this project. High quality pedagogy requires that I, the teacher, create an equitable and welcoming atmosphere for my students, emphasize the importance of exploring and taking chances, and provide valuable and relevant opportunities for discovering new perspectives and knowledge to all my students no matter what culture or socioeconomic standing they might come from. Therefore, exploring research on how I can best inspire my students to work together towards achieving a high-level mastery of mathematics is essential. Since students have varying strengths, values, and interests as a foundation for connecting to new learning, I need to constantly incorporate new strategies and provide a variety of materials that will aid my students in learning new ways of thinking about the world.

Procedures for the Literature Review

I selected literature for this review based on three themes. One of my key research themes was focusing on research on culturally responsive pedagogy. In looking for high-quality articles on this topic I looked for the following descriptors: multicultural education, educational equity, culturally responsive/sustaining/revitalizing, equitable education/classroom, collaborative learning, and other similar searches that provided articles that helped advise me on how I can transform my classroom to include all students no matter what their background is. Many searches such as “culturally responsive pedagogy” yielded over 100,000 hits on Google Scholar, so I started adding other key search terms and I increasingly used the data base of the Hamersly Library at Western Oregon University. Whenever I found abstracts that looked like the article would be helpful towards creating a learning environment that would empower diverse student populations, I downloaded a copy of that article on WOU and read it. Then using my increasing awareness of articles, I sometimes looked for similar articles to help further explore strategies

and other ideas. In the end, I discovered many fascinating articles that discussed racially diverse groups such as African Americans, Latinx Americans, and Native Americans and how as a teacher I can make education more inclusive and culturally relevant to my students.

Another theme I focused on while exploring the research was finding strategies to show my students that they are valuable members of my classroom. In my searches on teaching strategies, instructional techniques, and organizing instruction in clear and flexible ways, I discovered several abstracts that showed an emphasis on a variety of strategies I might use in teaching such as call and response, multiple frameworks for creating and organizing a course, articles emphasizing the importance of creating clear learning goals and a structure that enables students to reach these goals, and an environment that gradually releases students to becoming increasingly active and independent in their own learning acquisition. Providing clear and flexible lesson plans and empowering students to become increasingly active in their own learning is essential towards creating a valuable and relevant atmosphere that will enable my students to achieve their goals and become productive and independent citizens.

The final major theme that drove my searches and development as a teacher was finding articles that will assist me in creating a smooth and positive mathematics learning environment. In my searches relating to mathematics pedagogy, I discovered many useful strategies for teaching mathematics such as creating clear and simple learning targets that help my students focus on expanding a few key skills at a time, using consistent assessment criteria that inform the direction of my teaching and assist my students in understanding expectations, using acronyms and other simple organizational tools that aid my students in developing early schemas that will assist them in their own development, using solved examples that focus on the reasoning behind mathematical procedures, and starting with concrete examples before building in increasingly

abstract representations. Providing clear instruction and expectations, frequently assessing my students for understanding of the material, gradually releasing my students towards increased responsibility, and providing organizational tools that help guide early mathematics reading, writing, and thinking skills is essential for creating a smooth learning experience for my students.

Organizing the Research

This research study combined strands of complementary research literature, centered on three sub-themes. First, I discuss the theme culturally relevant pedagogy and creating a unified classroom filled with strategies that encourage collaboration and pooling our knowledge together to co-construct a deeper richer meaning. Second, I focused my research on clear and simple goals, strategic teaching to reach these goals, and an emphasis on assessment that encourages flexible thinking and growth both for students and for the teacher alike. Subtly filling in gaps in student understanding while introducing activities that they consider to be engaging, valuable, and relevant to their lives, will enable me to create a more motivated classroom filled with a desire to explore and learn. Finally, I looked at research on specific strategies for developing high-level thinking skills in mathematics while simultaneously reducing cognitive load while learning mathematics. These three interrelated subthemes help organize my thinking and provide a framework of this Action Research Project.

The third subtheme for me was especially enchanting to research and reflect upon. Mathematics, like other content areas, has its own style of reading, writing, and describing. Compared to other disciplines, mathematics is an extremely dense language filled with whole numbers, negative numbers, proportions, symbolic notations and representations, and other abstract skills. Many of the foundational skills that mathematicians rely on to connect and

synthesize all the meaning we see when we look at meaning-packed algebraic language statements and graphic representations allow us to synthesize deeper meaning and higher-level thinking. Like a seasoned driver, mathematicians have learned to automatically see all the deeper messages and understand many of their implications. For students, however, who have usually not mastered earlier foundational skills, including relating mathematics to concrete objects, developing an understanding of meaning-packed and abstract language is an extremely intimidating puzzle. Therefore, to reduce cognitive load, mathematics teachers need to simplify the puzzle pieces and focus on exploring one fragment of the puzzle at a time. Then, as students become comfortable with a wide range of puzzle fragments, they can start connecting it together and see math for the multi-dimensional clever art that it is. Developing this vast network of new perspective and meaning-making, opens students to a whole new world and literally enables them to frolic in new dimensions of thinking! Therefore, as their instructor, I was fascinated to read a multitude of clever strategies for providing clear, organized, and flexible guidance towards developing mathematical language skills.

Culturally Responsive Pedagogy

There are three common themes I found in research that drove my early thinking about what it means to be a great teacher. One common theme in many research studies is the importance of providing consistent opportunities for students to work in groups and for these student groups to explore and co-construct meaning (Lee, 1998, Gay, 2002, Howard, 2019, Banks, 2019, Adjapong & Emdin, 2015, McCarty & Lee, 2014, Nelson-Barber and Estrin, 1995). The literature makes it clear that working together to co-construct meaning and procedural knowledge not only will enhance learning, but that the unity created from group

interactions will also provide a healthier atmosphere in which students can freely contribute their knowledge to benefit the greater good. The research further posits that many racially diverse cultures including African Americans, Latinx, Native Americans, and many Asian cultures value collectivism and the pursuit of the greater good of everyone. Classroom unity is a bedrock for learning and therefore is stressed by many researchers.

Another idea that drove much of the research about creating an equitable classroom was an increasing awareness of racial and socioeconomic conflict within our society. Critical race theory is well-supported in literature, which clearly demonstrates that people of color tend to be highly segregated to poorer areas with higher crime, receive a lower quality and biased education, decreased prospects for accessing high-paying occupations, reduced opportunities to receive low-interest loans, and much higher incidence of inequitable and unfair treatment. The research clearly demonstrates that racially diverse people and White upper-class students tend to be highly segregated and therefore their opportunities and who they interact with is largely determined by where they live. Wealthier schools tend to be in richer neighborhoods, which tend to have higher taxes and more resources (e.g. teaching, high quality curriculum) available to students. Conversely, poorer schools have lower property taxes, much more affordable rental costs, and tend to be a lot more racially segregated. Critical race theory shows us that U.S. society is still highly segregated and this affects who our students interact with and the resources their community has available to support them (Au & Yonamine, 2021, Banks, 2019, Gay, 2002, Howard, 2016, Ladson-Billings and Tate IV, 1995, Ladson-Billings, 2021, Sensoy & DiAngelo, 2017).

The final consideration that influenced much of the research on content responsive pedagogy was on inspiring students with teaching strategies such as call and response, hip hop

pedagogy, and other clever ways to include students in interacting more with their own learning. Gradual release of responsibility is very important, so when introducing new complex tasks, it is important to give students as many openings as possible to participate in building early meaning that will enable them to show off and teach their peers. People need to be acknowledged and respected, but they are often too confused by new concepts to share their thoughts. Therefore, creating a positive and even somewhat playful low-risk atmosphere, in which all thoughts are welcomed and expected, can encourage students to want to be included in meaning-making activities and explorations. To inspire students, teachers first need to immerse themselves in their thoughts, beliefs, values, cultures, and interests. Only then is it possible to create a playful engaging atmosphere for learning (Ladson-Billings, 2017, Baker-Belle, Stanbrough, & Everett 2017, and Adjapong & Emdin, 2015).

Unity is Fundamental in a Culturally Responsive Classroom

Creating a culturally responsive classroom with a positive atmosphere requires that all students feel included. Au and Yonamine (2021), Banks (2019), Duncan-Andrade (2009), Howard (2016), Ladson-Billings and Tate IV (1995), Ladson-Billings (2021), and Sensoy and DiAngelo (2017) all recognize that inequity is deeply embedded in the very roots of our society and that this attitude spans not only across economic differences, but also in the way we treat each other and think about people from other socioeconomic classes. They all emphasize that we need to learn to look past our differences and unite so that together we can create a better and more prosperous country. Researchers overwhelmingly agree that we need to pave a path for our children to look into the very chasms of conflict that we have created and see these holes not as scary obstacles to be avoided, but as opportunities to collaborate with one another and make a

healthier and happier future for all of us. Therefore, creating an atmosphere in which students collectively try to grow and learn, sharing their own experiences and knowledge as they do so, is a requirement of a culturally sustaining classroom.

Culturally Relevant Pedagogy Means Valuing Different Cultures

Researchers also bring up a good point that unity only comes when teachers respect and value all cultural backgrounds in their classroom (Banks, 2019, Howard, 2019, Gay, 2002, Lee, 1998, McCarty and Lee, 2014, and Nelson-Barber and Estrin, 1995). These researchers observe that regularly bringing awareness to the contributions of different ethnic cultures plays a major role in developing and using academic subjects, since it helps students feel their identity is valued and this in turn helps create a motivated, positive, and unified classroom environment. They also recognized that valuing and connecting content knowledge to other values, beliefs, and interests enhances student motivation. Nelson-Barber and Estrin (1995) give an example of creating a culturally sustaining curriculum that includes mathematics activities such as rug weaving and cooking, which are valued by many Native American cultures. Including important traditions for a wide variety of racially diverse students will help them identify and connect with the material. The literature clearly supports that teachers need to be aware of and openly value all their students' backgrounds and cultures.

Research also clearly shows that there is a need for teachers to be explicit, provide rich contexts for learning, and create opportunities to learn in groups. Banks (2019) observes that many African American children are familiar with explicit instructions in their home, so seeing this in school helps make the classroom feel familiar and homely. Gay (2002) observes that many racially diverse cultures also use colorful and rich context when explaining events in their

lives. Therefore, incorporating rich contexts in a classroom could also aid students in developing new ways of thinking and approaching the world. Banks (2019) also reflects on how females, Latinos, and many other students also share collectivist attitudes and value collaborating in community activities that benefit everyone. Ladson-Billings (1995) further expands on the research by highlighting that promoting a buddy system, in which each student has a peer that they can rely on to help them with classwork and homework, can be very helpful for many students. The research shows that culturally responsive pedagogy requires that teachers be aware of students' communication styles, be explicit in their instruction, create rich contexts to support learning, offer opportunities for group activities, and encourage a buddy system that will aid students in helping each other in classwork and homework.

Culturally Responsive Pedagogy Requires Strategic and Flexible Guidance

Researchers overwhelmingly agree that music and hip-hop culture can support learning since they create a light-hearted, positive, and productive environment that touches our souls and inspires us to conquer obstacles and work together towards creating a better future (Ladson-Billings, 1995 & 2017, Kwon & Ríos, 2019, Baker-Belle, Stanbrough & Everett, 2017), Adjapong & Emdin, 2015). They also emphasize the importance of giving students opportunities for advocating for making a difference in their community. Through hip hop pedagogy and teaching strategies such as call and response, students become leaders of change in much the same way as teachers. In placing students in roles of leadership and responsibility, students not only demonstrate how to reason mathematically in front of their peers, but they themselves also learn to take up the identity of mathematician and to look at the world through new eyes. Through this new perspective, students have the opportunity to achieve an even higher objective;

they get to demonstrate their ingenuity and resourcefulness right in front of their peers! Their fellow classmates will look at them in awe, admiration, and respect as they analyze public information related to their community, explain problems their community faces, and come up with real solutions that will make their community and possibly even the entire country or world a better place (Ladson-Billings, 1995).

Backwards Design Helps Guide the Direction of Good Teaching

Wiggins & McTighe (2005) observe that a high-quality course starts with a carefully laid out plan. Backwards design guides teachers in seeing what this plan looks like. Instead of haphazardly leaping into a lesson plan and continuing to improvise as teachers witness how their students perform each day, teachers should create a plan with their larger unit goals in mind right from the start. By focusing on these big picture ideas and large-scale reasoning skills, teachers can then think about all the skills and academic language needed to reach those lofty goals. Then, with a clear course framework in mind, teachers can design and deliver consistently clear and structured daily lesson goals, high-quality activities, and assessments. Additionally, understanding the end goals and the necessary ingredients needed to successfully reach them, enables the teacher to clearly instruct students what skills they should be developing. Providing this clear direction then allows students to focus their attention on the right things, which enables the teacher to see how students are interpreting the material and what activities might be made to help fill in gaps in understanding and guide students to question their misconceptions through carefully constructed activities. Understanding the nature of the river towards the end goals permits teachers to create a smoother path downstream in which the rocky tempestuous sections are less treacherous. Backwards design guides teachers in discovering potential paths forward in

the same fashion that the resulting clear instructions guides students to understanding the expectations along the way.

Students Need Support to Connect to New Ways of Thinking

Buehl (2011) points out that people have varying schema that help guide our ability to make sense of new knowledge. Schemas are networks of related information and experiences that help us make sense of what we are observing and learning each day. Students have a wide variety of subjects and different ways of thinking that they need to develop schema for. In a typical school day a student may venture into the realms of art, dive into the abstract language of mathematics, traverse the complex meanings of English literature, and analyze how geography has affected historical events in the United States. Each subject requires different kinds of background knowledge and experiences to help students make sense of everything they are learning. With so much on each student's plate, teachers need to include references to knowledge students can connect with and relate these references to new academic material. Buehl (2011) also recommends using videos, visuals, and think-aloud strategies to help students better connect with material and smoothly add new academic schemas to their arsenal of knowledge and ways of thinking.

Clarity and Flexibility are the Heart of Teaching and Learning

Researchers overwhelmingly agree that clear directions and flexibility in learning goals and assessments is essential for learning. Research emphasizes the importance of creating clear and concise instructions every step of the way in the teaching and learning process. They also accentuate the need for teachers to be flexible and inspire students to be themselves as they

develop new understanding, make new connections, and express their thinking process. Knowledge is built upon experience and this foundation is the bedrock of making new connections. Since everyone has lived a unique and colorful life, each student needs frequent opportunities to communicate how and why they are thinking and reasoning through newly presented ideas. Since student's identities are the fabric of their interpretation of the world, teachers need to be open-minded and appreciate a wide variety of techniques students might use to demonstrate their intellectual and emotional growth. Providing a clear direction in a course and then being flexible as students express themselves in class and on assessments is supported by research and is at the very heart of good teaching (Au, 2016, Lalley and Gentile, 2009, Marzon, 2013, Tomlinson and Moon, 2013, and Wiggins & McTighe, 2005).

What Does Clear Instruction Look Like?

There are many elements that go into clear instructions. Simmons (2020) speaks of the importance of finding the correct pacing to each lesson. If a teacher goes too fast, the students will be overwhelmed and won't understand what is happening. Likewise, going too slow is problematic as students will become bored and may zone out. Additionally, going too slow could lead to teachers running out of time to cover other key aspects of the unit or course. Therefore, Simmons (2020) advises teachers to find the key pacing of each lesson by practicing essential components. For example, if the key theme of a lesson is modeling how to make a mathematical graph, then teachers should focus on how they are going to introduce the key components of graphing. This will give teachers an opportunity to hear themselves speak and judge whether their phrasing and timing of their instruction gives students just the right information in just the right amount of time. Preparing to demonstrate the most vital aspects of the lesson will also help

a teacher feel more confident and ready to instruct their students in essential skills in each unit. In the same way that practicing helps the students get a clear understanding of the material, it also aids the teacher in finding the right phrasing and pace for each day of class.

Gottlieb and Ernst-Slavit (2014) observe that clear instruction is all about building on a foundation that relates to contexts students are familiar with. In most of the experiences we have in life, we use context to help guide our thinking. For example, gestures can be very helpful in a lot of situations. If someone points to a loaf of bread and asks, “Can you please grab the bread over there?”, then that helps advise us where to look for the bread. Likewise, understanding who we are interacting with, will help guide the way we talk. When discussing the possible treatment for cancer, a medical doctor will speak very differently when seeking advice from a fellow colleague than when s/he is breaking the bad news to a family member, or the person diagnosed with cancer. Context is not only in everything we do, but it is also the very meaning that dictates how we think, feel, and react to the numerous decisions we make on a daily basis. Academic subjects such as math are no different. Telling students about x’s, y’s, and alike terms isn’t enough. Teachers need to make it clear what is the context of the question. What does x and y stand for? For what purpose are we using these symbols? Context is vital in our path as human beings to find clear meaning and therefore teachers always need to provide a context to help support student thinking. Gottlieb and Ernst-Slavit (2014) emphasis on providing context is relevant to all learning.

What Else Makes High-Quality Instruction?

Lalley and Gentile (2009) focus on the importance of increasing student’s awareness of their own progress and mastery of the material. This self-awareness will boost student’s morale

and self-efficacy and will encourage students to tackle new challenges. Additionally, knowledge builds on itself, so just like stepping stones, being aware of all the new skills they have acquired, will enable students to more readily use those same skills. Students can then more readily expand further upon their thinking and make new connections they might have otherwise missed. Teachers therefore need to design clear objectives that accentuate high standards for their students to master. Enabling students to develop a growth mindset is one of the most fundamental requirements to learning. Students need to believe that their effort is worthwhile, valuable, and relevant in their lives. Making a vast network of connections not only feels good, but it shows students that they have power in their lives. Mathematics reasoning and procedural skills, just like a sport or any other activity, are built upon dedication and practice. By bringing awareness to student's progress, teachers can help amplify the same sense of dedication and commitment to practice that is so essential to learning. Lalley and Gentile (2009) also argue that overlearning and enrichment activities are also essential in helping students solidify their own understanding of the material. Three enrichment activities that can assist students in solidifying their mastery in mathematics include analyzing and interpreting data, teaching their peers, and making and solving their own math questions.

Davies (2011) observes that acronyms and other tools that aid in organizing one's thoughts and creating a framework for thinking can help reduce cognitive load in mathematics and promote learning. Davies (2011) examines that acronyms such as SUNA (Show Steps, Use Units, Neat, Accurate) can really help students become increasingly aware of how to start mathematics problems. SUNA is especially memorable once students discover what it spells backwards! Davies (2011) argues that creating a lighter mood will provide students with an atmosphere more conducive to discovery and learning. Acronyms and other learning tools that

help organize thinking can be instrumental in providing students the additional support they need to get started in their journey of discovery and learning!

Another skill that is essential for students is to learn to ask deep and relevant questions. Wiggins and McTighe (2005) observe that overarching questions and topical questions, two forms of deep and relevant questions, both play a major role in informing students why the material they are learning is important. Overarching questions are deep questions relating to how a concept or strategy can be applied to real-life situations in general, while topical questions entice the learner to explore the deeper meaning behind specific situations. Learning to see the big picture and also learning to focus our thinking on certain contexts are both essential skills that help students become independent thinkers, analyze deeper and richer meanings in each content area, and helps guide us to make more informed plans and decisions. Asking a variety of deep reflective questions is a crucial skill that students need to see modeled several times. Then, in time, with encouragement and support, students will become increasingly independent in asking deep questions that help them enhance their own understanding of the material and develop increased competency in their intellectual pursuits.

Mathematics: Assessing for Understanding of Key Learning Goals

Standardized assessments help educators ensure that all students are receiving a high-quality education in mathematics (Schiller and Muller, 2003, Spencer, Steele, & Quinn, 1999, Kilpatrick & Johansson 1994, and Schoenfeld, 2015). This tracking not only tells us how the entire student body is doing, but data is also broken down to focus on student groups that historically have had lower performance such as African Americans, Hispanics, females, and students of lower socioeconomic classes. By studying more closely how each group of students

is being affected, administrators and educators can more effectively collaborate and find solutions for reducing inequitable gaps in providing the best possible education for everyone. More specifically, tracking students' performance over time, enables teachers and administrators to make appropriate adjustments to help students overcome gaps in understanding and keep those students on track to advance to higher level courses and graduate. Standardized assessment data enables administrators and teachers to offer more targeted supports and a variety of remedial and support courses that will keep students on track to graduate and achieve better outcomes in life.

While the positive impact of increasing awareness through assessment is noteworthy, researchers also acknowledge that there are notable drawbacks. One of these drawbacks is that while these assessments help bring great awareness to how well all student groups are understanding mathematics content, this awareness is not always a good thing. Several researchers examine how stereotype threat can negatively affect many of our student groups (Schiller and Muller, 2003, Spencer, Steele, & Quinn, 1999, Lomax, West, Harmon, Viator & Madaus, 1995, and Cooper & Dunne, 1998). Historically, many racially diverse groups including Hispanics and African Americans, females, and people of lower socioeconomic status have struggled in mathematics. Heightened awareness of this poor performance leads many student groups to avoid any task that they perceive as dangerous to their sense of self-worth. Students will therefore avoid advanced level mathematics courses, SAT tests, and other math-related activities that might threaten their self-esteem and well-being. Some students will even handicap themselves in other ways to justify their inevitable low performance. In this way stereotype threat reinforces itself and awareness of low performance leads not only to lower academic outcomes, but also to potential harm to our students' emotional well-being. Going forward in time, awareness of stereotype threat is empowering educators to focus on new assessments that

will focus on students' strengths while still providing data on specific knowledge gaps.

Many researchers observe that while testing standards create accountability and uniformity in mathematics, many multiple-choice tests result in students learning how to identify answers rather than fully understand the underlying reasoning behind those answers (Shoenfeld, 2015, Kilpatrick and Johansson, 1994, and Cooper & Dunne, 1998). These researchers deduce that tests could have the potential of helping educators better understand student populations and in doing so, these educators could then design standardized tests that focus on essential overall goals rather than just focusing on student's overall performance on a standardized test with a multitude of skills. With enough data on our students, researchers believe that an enhanced curriculum combined with much higher quality reasoning-based assessments could help create a more uniform path of learning. These researchers then argue that this in turn could help educators make more precise conclusions on each student's reasoning abilities. Currently standardized testing does not inform educators of each individual student's understanding, largely due to their emphasis on multiple choice identification, but scholars believe that if we become knowledgeable enough about how students learn, reasoning-based assessments could be designed that specifically focus on assessing each student's understanding of a wide variety of interrelated mathematical concepts.

While many researchers are actively involved in collecting data on learning and pursuing the long-term goal of creating high-quality reasoning-based assessments, some researchers also recognize that this goal has been targeted for many decades and that using data to support complex mathematical thinking and reasoning acquisition is not a one-dimensional task. These researchers recognize that mathematics is a complex and large field, with many potential paths of learning, and that even with the highest quality assessments, there will always be

limitations on the conclusions we can make on what collection of skills and thinking skills students are understanding and to what extent that they are understanding these new ways of thinking. This conundrum of assessing where students are in their acquisition of reasoning skills and understanding the purpose of mathematical language and visual representations and the resulting procedural skills thereof, has long plagued researchers dedicated towards finally making clearer conclusions of what direction research needs to go to empower and better guide both student groups and individuals on their path towards becoming mathematicians.

Cooper and Dunne (1998) ran an especially clever study in their pursuit to understand how even positive performance results in assessments can be misleading. In a study that tested and interviewed 140 primary students aged 10 and 11 and 450 secondary students aged 13 and 14, Cooper and Dunne (1998) discovered that students, using appropriate social-class recognition rules, were often able to correctly surmise the answers of realistic and familiar types of multiple-choice questions based on context and by eliminating less likely answers. In comparison, however, esoteric questions that focused on very specific and less common knowledge, disproportionately and perversely affected working class children in their study. Based on this data, Cooper and Dunne (1998) highlighted that esoteric questions create a major problem in equitable testing. Also of note, the interviews clearly showed that even when children were able to correctly answer familiar questions relating to common-place activities by using relevant social-class recognition rules, they were unable to explain how they had done so mathematically. The interviews, in fact, often show that these students were not even able to give a basic explanation for what they had done. Therefore, Cooper and Dunne (1998) strongly advise administrators and educators to be cautious when analyzing and interpreting assessment results of student achievement in math-related goals. Especially with multiple choice testing, Cooper

and Dunne (1998) stress that educators can never be sure whether students are using recognition strategies to identify an answer, whether they are memorizing procedural skills and haphazardly using them on a test, or whether they are genuinely understanding the material.

Schoenfeld (2015) observes that the SBAC standardized assessments could become much more geared towards achieving high-quality goals as highlighted in the Common Core State Standards. He especially underscores the need for mathematics reform in the United States. Schoenfeld (2015) also observed that a reasoning section is planned to be integrated into the SBAC assessment. He claims that with the emergence of increasingly clever artificial intelligence, that testing can finally veer away from being multiple choice to focusing on students mathematical thinking and writing. Schoenfeld (2015) argues that throughout the United States artificial intelligence technology can evaluate student thinking and summarize what knowledge each student demonstrates. Additionally, he posits that high quality assessment websites that encourage student exploration and construction of thoughts can further aid students in knowledge acquisition. He advocates strongly for teachers using the Mathematics Assessment Project's (MAPs) website as those activities prioritize student exploration and development of new ways of thinking. By utilizing high quality learning activities and assessments, and by developing artificial intelligence geared towards evaluating students' reasoning skills, Schoenfeld makes a good case that the SBAC and other assessments could be reengineered to become much more supportive tools of teaching and learning in mathematics.

Strategies for Teaching Mathematics

Chval and Khisty (2009) examine a wide arsenal of teaching strategies that can make a big impact in achieving positive outcomes in mathematics. To do this, they studied why an

exceptional Iowan math teacher named Sara was able to raise her students' mathematics academic level significantly in only one school year. Sara demonstrates that by giving students many vocabulary-rich math problems, facilitating conversations around those math problems, accentuating and demonstrating the importance of writing and reflection as a daily activity, and always providing personalized feedback, students can develop and learn new complex skills. Her high expectations for her students to be able to clearly explain concepts aloud and in writing, and her frequent modeling of mathematics thinking drove her students to stay motivated and clearly understand their path towards becoming innovative and fluent mathematical thinkers and writers. Sara recognized that she teaches at a school that is nearly 100% Latino and had clear structure that allowed her students to achieve their very best. Sara explicitly taught her students that English words such as combine, clarify, and represent all had extremely similar cognates in Spanish. In this way, Sara helped her students utilize their background knowledge and strengths as a bedrock to acquire new meaning and bring awareness to similarities between two different languages. A combination of clear instruction and daily discussion and writing allowed her students to achieve much better outcomes than other fifth graders at her school and throughout her district and the United States. In only one school year, Sara's students on average grew by 1.8 grade levels while other fifth graders in the same school grew by 1.2 grade levels and fifth graders in her district and nationally grow by 1.0 grade levels.

Many students, especially those with learning disabilities, struggle with a variety of interrelated math areas of knowledge including basic facts, operations, proportions, word problems, and algebra. For this reason, researchers overpoweringly agree that mathematics teachers need to be explicit in their instruction, provide specific feedback, and visuals need to be regularly incorporated into every lesson (Doabler et al., 2016, Torres-Velasquez & Lobo, 2004,

2010, Abdullah et al., 2012, Bouck et al., 2018., Strickland & Maccini, 2010). Mathematics teachers also need to use a wide array of visuals and explicit modeling for their students. Many researchers believe that the concrete-representational-abstract (CRA) framework of teaching is extremely helpful for many students (Bouck et al., 2018., Strickland & Maccini, 2010, Miller & Hudson, 2006). These scholars believe that students first need to see and interact with physical objects and how mathematics can be used to describe them. After seeing and interacting with physical objects and the mathematics associated with those objects, teachers can then model and explain thinking that revolves around graphs and other representations. Finally, in the last stage, teachers can then relate those representations to symbolic mathematical language. To assist students with foundational math skills, operations, fractions, real-life word problems, and algebra teachers need to provide explicit instruction, specific feedback, and a variety of visuals for all three CRA phases of learning.

Teachers also need to be ready to give additional supports, be empathetic and value all student cultures, make learning new concepts as smooth as possible, and provide opportunities for interesting and valuable individual and group work (Kortering et al., 2005, Brookhart, 2015, Torres-Velasquez & Lobo, 2004, Ladson-Billing, 1995). By encouraging students to express their opinions in surveys, analyze data in their community, use data to reflect on potential innovative solutions, and make proposals for positive change in their neighborhood, teachers empower their students while simultaneously providing a context that encourages students to develop high-level mathematical thinking, reading, and writing skills. Math diagrams, charts, and graphs can be packed with culturally relevant information. Other researchers suggest providing this caring and culturally relevant atmosphere by embedding other cultural aspects into the classroom including setting aside time to learn key mathematics vocabulary and emphasizing

mathematics cognates that will make the learning process smoother (Doabler et al., 2016, Chval and Khisty, 2009).

Another consideration teachers need to make when providing helpful visuals is how to focus on conceptual reasoning while minimizing cognitive load. Cognitive load theory says that humans have limited working memory and that when we are overworked, our capacity for learning significantly decreases (Riccomini & Morano, 2019). Researchers prodigiously agree that solved examples enable students to develop foundational reasoning skills that will support them in understanding why each procedural skill works (Riccomini & Morano, 2019, Mwangi & Sweller, 1998, Mavilidi & Zhong 2019, Fuchs et al., 2016, Heitin, 2015). Providing solved examples for class practices and assignments reduces students' cognitive load and helps them focus on learning to reason algebraically and gain an increasingly deep understanding how and why mathematical procedures work. Researchers stress that teachers should give their students plenty of opportunities to master the reasoning behind solved examples. Only after students have had a chance to examine several solved problems, both in whole class discussion and being assisted in small groups, should teachers gradually release students to practice those same procedures themselves. Giving students time to master conceptual understanding is vital since this mastery will enable them to self-explain the process of thinking like a mathematician. As students tackle increasingly complex challenges, their ability to be self-directed will play an indispensable role in their ability to continue to expand their thinking.

CHAPTER 3

RESEARCH METHODS

The methods of inquiry for this study focused on the principles and practices of action research, using self-study aligned with professional teacher standards, teacher artifacts, and student grades as a means of data collection. I will begin with a review of action research principles to establish the foundation for this study's method of inquiry. Second, I will review the choices and purposes of data collection that helped to highlight my instruction and means for searching for improvement. Third, I will detail my context for the study, methods of data collection protocols, maintaining credibility and trustworthiness of the data, and acknowledge my limitations as a researcher. Finally, I will present the procedures used for studying my practice, while providing data and analysis that speaks to adaptations and adjustments made to my instruction as I implanted this study.

Research Questions

My focus for this research was to make the mathematics learning experience smooth and relevant for all my students. Specifically, I examined student work samples and grades to help inform me whether my students were making connections to mathematics content. Additionally, I studied students' revisions based on personalized feedback and activities I provide them to aid them in their mathematics learning. This focus aligned with the following InTASC Standards for teacher professional development since it aided me in my development of creating an environment that values my students, brings them high quality content that relates to their lives, and utilizes data from assessments to inform me of improvements I can make in my teaching.

Additionally, I considered how studying my own practice in line with InTASC Standards could improve my own instruction and therefore, student learning. My purpose of this study was to use my own observations, artifacts, and assessment data to inform me how I can improve my teaching thereby inspiring students to engage in their own learning and development. The research questions for this study were:

1. How can I inspire students from a wide variety of backgrounds and provide better personalized supports for all the individuals in my classroom? I seek to create a more engaged classroom atmosphere. In most math classrooms I have observed students only participate so that they can get a good grade and most students mimic the teacher rather than actually understanding the mathematics procedures they are writing. This leads to numerous misconceptions and gaps in understanding. Therefore, by providing personalized feedback I am hoping to better assist my students in understanding how mathematics works. Data gathered from this focus question was used to enable me to see how my feedback assists in my student's growth and understanding of mathematics.
2. What strategies can I use to emphasize my students' assets so that every student can see that they are valuable, and their contributions are essential for the greater good of the classroom and of society? Many students get discouraged in school and this is especially true in mathematics. Many students in a math classroom have a fixed mindset and these students believe, "they just aren't good at mathematics". Additionally, many students avoid sharing their thoughts on a mathematics question or concept. Since a growth mindset is essential for learning, I seek to find ways to encourage students to participate and share their thinking. Data gathered from this question was used to validate teaching strategies that I can use that best encourages students to be more involved in their own learning.
3. What strategies and assessments can I use to make the mathematics learning experience smooth and positive for all my students? The goal of this question is to understand how I can better

instruct and use assessments to guide my instruction so that my students can learn how to speak and write mathematically. Mathematics is a very dense language, with a lot of symbolic vocabulary, and complex syntax. Therefore, assessing for and focusing my instruction on the mathematics language skills my students need most is fundamental in building a strong foundation for future mathematics learning. Data gathered from this focus question was used to describe my students' needs so that their learning experience goes smoothly, and the learning experience feels valuable for all my students.

InTASC Standards

The InTASC standards are a set of standards that teachers strive to attain so that they can provide a positive and productive atmosphere for all their students and everyone else in the community that they interact with. Teachers are the role models of future generations and therefore it is essential that we model ways that will helps our students be happy and healthy adults. This includes not only modeling content area skills, but also provides a healthy collaborative environment. Teachers do this not only by maintaining a positive classroom atmosphere, but also regularly interacting with parents and administrators to ensure that everyone is involved in supporting all our students. Strong communications with students and their families also enables me to constantly develop new ways of scaffolding and differentiating within my classroom so that all students feel supported, respected, and valued. Interacting with other administrators, teachers, and other professionals also gives me invaluable professional development. The InTASC standards will help guide me in providing all my students the education they need and deserve to live fulfilling lives.

I am always trying to find new ways to inspire all students and give everyone as many opportunities for success as possible. I believe that every individual is unique, and I seek to find

every way I can to provide the personalized caring supports that each of my students needs. Therefore, one of my research questions is directed at finding ways to better provide personalized supports that will inspire my students to strive for higher standards. I also want to show my students that they matter by emphasizing their strengths in my classroom and show them how they can use those strengths to succeed. My second research question seeks to find ways that I can show every student that they have valuable talents that are important in my classroom. Additionally, I am aware that mathematics, my content area, is one of the most difficult subjects for many students to master. Mathematical language and visual representations are abstract and filled with complex meanings. In order to best facilitate my students' success, my third research question seeks to find ways to make the mathematics learning process as smooth and positive as possible. This action research is meant to guide me in providing a personalized and smooth learning experience for all my students and to inspire them to continue to grow and develop alongside me.

Methods and Procedures

My purpose was to describe my own teaching practice as well as how I use data to improve my own practice in line with the InTASC professional standards. For this reason, it was important to choose a method that could account for both what the standards are for teachers and how I was paying attention to my own practice through data collection to improve it. Accordingly, this study was designed as an action research study. Action research is the steps I will take to improve myself as a teacher and a leader of the next generation. Above all else it is important for me to maintain awareness of myself and of my students. Action research is a

means by which I can achieve this self-awareness and become more insightful of where my students are coming from and how I can best assist them.

Action research can be achieved in many forms. One common form is by journaling what works and what doesn't. I will therefore make journals of advice I receive from my mentor teacher and supervisor and using this advice I will prepare questions I can ask my students to assist them and show them that they are assets in my classroom. Additionally, I will journal and utilize other advice like how I might change my mannerisms, how I can create better and more positive relationships with my students, and how I can improve my lesson plans and assessments to be more explicit and make expectations clearer and more achievable. I will also keep and organized notebook just like my students so that I can better understand the tools I am providing my students and how I might improve the notes and classwork activities I provide them. This will also assist me in creating increasingly meaningful and helpful notes and activities that will guide my students in developing a positive self-efficacy in my class.

I will also keep written suggestions on how I can improve my teaching. My supervisor provides me with very detailed feedback, which will further help guide my action research and show me ways I can continue to improve my craft. By reading these observations and highlighting key ideas for improvement, I can then try to incorporate these ideas into my lesson plans and teaching. My lesson plans are always detailed and therefore by reading past lesson plans, I can then become increasingly aware of what went well and what improvements I can provide a smoother and more positive learning experience that feels more valuable for my students. Becoming more aware of my own development in lesson planning while simultaneously being increasingly aware of the guidance I am being given during observations will enable me to write increasingly reflective lesson plans.

Data Collection

The basic steps in action research are 1) identify a topic or issue to study, 2) collect data related to the chosen topic or issue, 3) analyze and interpret the collected data, and 4) carry out action planning, which represents the application of the action research results. Data collection in an action research project typically is related to the topic or issues and provides answers pertinent to the research questions. As Padak and Padak observe, "Any information that can help you answer your questions is data" (p. 3, 1994). Therefore, I used a variety of data collection tools related to my topic to ensure the validity of my results. Furthermore, I adhered to the following four characteristics in determining the data I would collect for my study, 1) anonymity of students, 2) comparison in data collection was built in so that the results could be judged against themselves both before and after the intervention period, 3) aspects of performance to be examined were identified prior to data collection so that the information was relevant and connected to the research questions, and 4) a variety of data was collected so that different aspects of the topic could be brought to light (Padak and Padak, 1994). Finally, because I was studying my own practice while I was in the middle of said practice, I acknowledge the "spiraling nature" of data collection in action research (Padak and Padak, 1994). By focusing on data in connection to my research questions, my action research enables me to reflect on what strategies I can use to improve my teaching.

Because my research questions focus on emphasizing students' assets, inspiring them to use this knowledge to make a difference within my classroom and later in life, and making the mathematics learning experiences smooth and valuable to all my students, I chose to collect data

that would provide information about how my practice and the interventions I identified aligned with the research topic. The types of data I chose to collect are described next.

Journaling To Increase Awareness

By journaling each class what worked well and what didn't I become increasingly knowledgeable of what kinds of activities best engage my students in learning mathematics. All my research goals can only be achieved if my students are motivated to learn and they themselves see their mathematics learning experience in some way as being valuable and relevant to their lives. The mathematics content area can be applied to just about any topic and a huge array of strategies can be utilized to model and demonstrate the language and purpose of mathematics. Therefore, discovering what mathematics activities my students can most easily engage with and uses collaborative learning strategies that will inspire students to become increasingly involved in their own education is essential. This is a skill that many mathematics teachers struggle with, so by intentionally making notes on what strategies are going more smoothly, the awareness can help me guide the direction of my course in a way that will be healthier and more fulfilling for my students.

Observations and Advice from Experienced Teachers

To create a positive and smooth learning environment, I need to create an atmosphere that promotes focus and encourages students to become independent. Many teachers I have observed struggle to inspire students to become independent mathematics thinkers, discussers, and writers. Therefore, to enable my students to become increasingly independent and confident in their own skills, I need to provide a structure and environment in which everyone feels their

voice and ideas are valuable and essential to the success of the classroom. To encourage this healthy sense of collaboration to begin, I will try utilizing a wide variety of tips that my mentor teacher and supervisor give me for creating a classroom that is focused and engaging on learning mathematics. Providing a structure in which my students can easily focus and feel free to take chances is fundamental towards opening dialogues that are essential for learning. My mentor teacher and supervisor are both experienced in classroom management techniques that can help me accomplish this and they have several other ideas that are invaluable towards my growth as a teacher.

Videos That Capture Learning

I will also create 3-5 videos that help guide me towards improving my craft as a math teacher. In mathematics the exact way I phrase key content and skills my students need to learn is vital. My phrasing needs to be simple and clear and capture the larger state standard skill I am trying to scaffold. Therefore, I will take a few videos to help me reinforce my journaling for how I can improve the way I phrase and model concepts to make the learning experience smoother and empower students to understand and use mathematics to create a more independent and positive classroom atmosphere. Math is stressful for many students since it is a complex language and translating mathematics into English is a challenging skill to learn. By conveying clear and simple learning targets, demonstrating key concepts as simply as possible, and providing summaries of key concepts and why they are important, I can greatly increase my students' access to a smooth and valuable learning experience.

Context of the Study

I serve a large high school in the Willamette Valley in Oregon. This school serves around 2000 students, 9th through 12th graders. In the mathematics wing of the school there are usually about 30 students in each class. On Wednesdays, which is late start in my district, our Professional Learning Communities gather, and we make plans for what activities and structure that will best support our students in gaining proficiency in a collection of state standardized mathematics skills. My school is arranged on a block schedule, in which we rotate between teaching 1st through 4th period and 5th through 8th period. Classes are generally 90 minutes long except on Wednesday, which is a late start PLC Day and includes advisory and a 1:1:1 club, sport, or support that each student attends. Wednesday classes are reduced to 50 minutes each so the lesson plans in the middle of the week needs to be shorter.

My school has a wide range of services available for our students. We have classrooms that specialize in providing extra support for English Language Learners, we have extra instructional assistants that provide personalized supports for students on an IEP or 504 plan, and my school has also recently implemented some innovative new classes to help increase attendance rates and motivation among our student populations. For example, 10th graders now have the opportunity to take a Geometry Construction class. This new class offers them real-life usage of mathematics and because it meets every day throughout the entire school year, students attending this class will earn one mathematics credit and they will also receive an elective credit!

My mentor teacher and I meet separately each week and talk about potential ideas and classroom management skills I can utilize to help provide a focused and engaged classroom environment. I currently teach one period of algebra I and soon I will take over a second period

of algebra. The algebra I teachers all stay on the same calendar so that we can all contribute ideas and materials towards the unit we are currently teaching. Occasionally, we also have a test retake day in class in which students that need to retake a test are given an opportunity to do so during that class period while other students are given more specialized supports by other algebra I teachers teaching that period. Having a united team that is determined to provide opportunities for our students to succeed gives us the freedom to share materials, swap students occasionally for more targeted supports, and brainstorm together how we might design materials to be higher quality and more helpful for our students.

Participants

Because this study was designed using an action research approach, the main participant in the study is myself, as the teacher. As my learning progressed throughout my student teaching program, I became interested in a number of ideas that would help me to improve my instruction. Ultimately, I decided to focus on the main research areas outlined in my research question. To lend credibility to the results I will share from my self-study of my practice, it is important to describe my role in the classroom where I teach. In this section I will focus on describing my own classroom and my role as the teacher. I have been teaching one class of algebra I for just over one month and I will soon take over another algebra I class. My mentor teacher encourages me to design my own materials, so I create several activities for my students each week. I follow a calendar that our algebra I PLCs made together, so I have a lot of structure on what is taught each class day. Many of our students have been struggling with the skills in each unit, but algebra I teachers are determined to finish our systems of equations unit just before spring break so that we can move on to other key units such as exponential functions.

Early in the school year I observed several algebra I teachers, and it is very clear that getting students to participate and become independent problem-solvers is an extremely daunting task. Students come into 9th grade feeling, “They are just not good at math” and many of them don’t feel math is relevant or valuable in their lives. A lot of the fundamental language skills we focus on as part of our College Preparatory Mathematics curriculum are also off-putting for our students, but many teachers feel this development of basic math language skills is a prerequisite for learning mathematics. Most teachers spend most of our time having students practice these language skills, and we are always going out of our way to ensure that students are staying on task. After seeing the very low motivation levels in our math classrooms, I am convinced that the math language skills we teach need to have an engaging context so that students gain a more natural understanding of why mathematics is important and are a lot more invested in their own education. Unfortunately, while the textbook and other materials do have a few cool contextual problems, I believe there is a desperate need for better mathematics learning materials in our classrooms. All the math teachers at my high school have their own family and with grading and helpful PLC meetings, we do not have enough time to dedicate towards finding more much more engaging materials that could help us structure an algebra I course to be much more motivating.

Math classes are all placed near each other ensuring that we can all easily support one another. Mostly I interact with my mentor teacher to take notes on new strategies and classroom management tips I can use to ensure that my class runs as smoothly and positively as possible, but I also have several other teachers that I can talk to as they understand what it is like to be a starting teacher in a subject that kids struggle in. Especially, now that we are coming back to school after t prolonged shutdowns, it is good to know that I am not alone in having students that are really struggling with basic graphing skills, basic algebra skills, and basic arithmetic skills.

Having colleagues that are all going through similar experiences enables us to share ideas on what we might do to approach teaching each concept differently. Additionally, all the math teachers at my high school have high standards for our students, and we have an awesome vice principal supporting us that used to be a math teacher himself! Having a team of teachers and an administrator that understands lack of engagement and attendance is the number one problem gives me hope that progress will occur at my high school.

The vice principal's top priority is finding ways to increase engagement in mathematics and in embracing this key goal he has most of the same philosophies I have. Additionally, he is actively collaborating with math teachers to introduce another cool math class on probability that can help improve student motivation and engagement. This class would likely be offered to 11th graders, since geometry construction was recently introduced for 10th graders, but I am hopeful that in time the leadership and teachers at McNary will come up with a more engaging version of algebra I since lack of engagement in 9th grade mathematics is clearly a top concern for all of us. Talks on how to redesign 9th grade math are currently in early stages, but currently an engaging 11th grade probability course is being proposed. This course would focus on relatable topics such as gambling in sports! If this context-rich course increases motivation as I expect it will, it won't be long before math teachers and our leadership come up with a similarly creative and engaging revised algebra I course and curriculum. The need for an engaging algebra I class is extremely urgent, so I am happy to hear that several qualified individuals have begun to look for solutions.

How I Studied My Teaching

In mathematics courses assessment is extremely important. One of the largest reasons students become disengaged in mathematics is because they frequently don't understand the

mathematics skills involved, they do poorly in assessments, and they feel investing their energy in learning such an incomprehensible language is not worth their time and effort. Therefore, my top priority is to continue to look for culturally relevant materials my students can relate to and enjoy and combine this with teaching strategies that helps students smoothly connect these relevant and valuable examples to mathematics. Making these connections smooth and unintimidating is a goal that all math teachers strive for, but all of us struggle with this. Over the last month and a half, I have also been trying to empower my students to succeed at least partially independently while still maintaining high mathematics language standards, and I can see that this goal will be an ongoing process.

Currently most math teachers spend a lot of time and energy devoted to managing our own classrooms and ensuring our students continue discussing mathematics rather than any other subjects they would rather be talking about. Therefore, right now I am also in the process of learning a lot of classroom management skills that will aid me in keeping my students on task and building their understanding of mathematics. While investing a lot of my multi-tasking mental resources on classroom management isn't optimal for a collaborative and engaged classroom atmosphere, I will also continue to invest a lot of time and energy in creating motivating materials. In time I believe I can make the mathematics learning experience smooth and relevant, and in doing so, encourage my students to invest the time and energy needed to master the mathematics language.

For just over a month, since I took over one of the algebra I classes, I have been designing activities that focus on getting my students actively involved in their own education. The first day of class I gave my students a short survey to discover their interests. This enabled me to start creating questions my students could relate to and better understand. I am a strong

believer that high school math classes should still be using word problems rather than exclusively practicing symbolic language our kids don't understand. The classroom management skills I am currently learning have also begun to help me keep students focused on building these key skills that will be instrumental in their success. Combining this with the fact that my students know I care about them, and I believe that in time I will have a whole classroom of students who will engage in math not just because I am hovering over their group, but because they themselves want to learn and they know those efforts will pay off.

The observations I have made tell me that this change will not come suddenly. While many of my students have grown to like me more since I took over a month ago, too many students currently believe that D's and F's are normal in math and that math is only for smart people. The curriculum and materials used in math classes are often abstract and very hard to relate to for many students. Therefore, by building positive relationships, and showing my students that I care about them, I can show students that I will do whatever I can to ensure that they succeed. Positive relationships are fundamental towards inspiring students to become more involved in mathematical discussions, thinking, reading, and writing skills. While self-motivation is still very low in most of the algebra classes at my school, I believe the atmosphere in my class is improving, if only a little. Additionally, I believe I am getting a better feel of what strategies and classroom management techniques are effective in my classroom. As these classroom management skills become more habitual and my confidence as a teacher continues to grow, I believe my success rate will also continue to grow. Additionally, the general management and teacher strategies I learn to use this unit, will be invaluable in making my next unit go more smoothly. Since many of the units my colleagues and I plan for during our PLC meetings only last 3-8 weeks, each unit will give me more practice to reflect upon, develop, and

practice strategies that will support my students. Being fully aware of my own growth and increasing success rates is a source of optimism for me. This optimism and satisfaction I get from seeing my own personal growth is essential since the high failure rate in math classrooms is a large reason many teachers get discouraged and this is a heavy weight for numerous caring teachers. Observations and reflection ***will*** empower me as a teacher and give me the courage and strength I need to continue to grow and successfully instruct my students in increasingly complex mathematical proficiency and interpretation skills.

In addition to journaling about the atmosphere of my classroom and collecting assessments that help guide my understanding of what my students know, I will also continue to take notes of suggestions my supervisor and mentor teacher make. The more skills I embrace out of habit, the more my students will sense my enhanced abilities and be inspired to grow themselves. Therefore, in addition to journaling my progress over time, continuing to add a couple more classroom management and teaching strategies to my arsenal of skills each week, will also enable me to model the same type of growth and mindset I want to see in my students. Luckily, kids are very perceptive and these changing currents in our classroom atmosphere will combined with the growing positive relationship we share, will empower all of us to achieve a higher understanding of mathematics and teaching together. Even now I am noticing many of my students are showing partial proficiency in some of the system of equations skills that we are currently learning about. I believe that in time these determined students will become proficient in complex mathematics skills and will in turn guide and support the rest of my classroom. In essence my growing skills will lead to more growth among my students, which in turn will help them solidify their skills by teaching their peers, who will also benefit from an increased number of teachers who can support them.

My journaling and professional development is largely geared towards the goal of creating a positive atmosphere in which students are self-motivated to explore without being pressured to do so. As I increasingly take notes on what works and develop the demeanor, dialogues, strategies, and intense confidence of a leader, my students will naturally begin to increasingly follow my lead. Therefore, my action research is based on journaling, awareness, professional tips I receive from experienced teachers, and my own development of numerous engaging activities to help my students buy into the identity of being a mathematician. Changing students' mindsets from, "I can't do math" and from not wanting to take chances in front of their peers to a growth mindset in which they want to take a leap of faith and try the activities I design for them will not be a quick or easy transition. This transition will, however, be a very satisfying one and I know my action research is helping me and will continue to aid me in creating a healthier and more confident atmosphere among all the students and teachers in my classroom. The day I look around the room and see more teachers besides myself is the day I know I have shown my students that math isn't a scary subject to be avoided, but instead a fun sport to be practiced and treasured.

CHAPTER 4

FINDINGS

Early Learning that Helped Drive My Thinking

Mathematics is frequently one of the subject's students struggle with the most. Early on in my teaching, I realized that most of my students struggle greatly with arithmetic including single digit adding and single digit multiplication skills and therefore this makes it very hard for students to identify and describe mathematical patterns. Many of these same 9th grade students are also intimidated by negative numbers and fractions, which are common components of symbolic equations and graphing. Since interpreting mathematical tables and equations and graphing those same equations are tasks I am responsible for teaching, it became abundantly clear early on that I needed to quickly provide helpful step-by-step handouts and clear learning goals and notes so that my students could focus on one small learning goal at a time and therefore make the learning as easy and smooth as possible. Making the learning experience smooth and giving students a clear understanding of what they are expected to understand and demonstrate is an essential component of making sure my students have opportunities to gain confidence in becoming proficient mathematicians.

The math teachers at my high school are all very caring people and we all put a lot of time, effort, and thought into all our materials. Our step-by-step guides, presentation, small group practice activities, and everything else become a part of our hopes and dreams to create a future filled with highly capable mathematicians. A part of us is therefore always optimistic, and even though all our assessments from the first semester yielded extremely concerning results, we felt that maybe if we phrase everything just right and build up the materials in incremental steps, our

students will be able to make the connections they need and fill in key gaps in their learning from the first semester. This new-found knowledge would be vital for helping students discover abstract solving techniques and in helping them construct interpretation skills involved in systems of two equations. The intentions and thoughtful design that goes into our creating an interactive notebook with our students, helpful handouts, guided whole-class discussions, and small group activities is nothing short of inspirational and my colleagues show at every turn that they are caring individuals that will stop at nothing to ensure our students succeed.

I first started journaling my observations and past concerns at the end of the systems of linear equations unit. During our first class in the system of equations unit, I was focused on teaching students to interpret graphs. To accomplish this, I provided contextual math problems relating total income to hourly wages and constant benefits. For example, if I am a college student looking for a part-time job, would I be better off getting a job that offers me $15 per hour and $200 in benefits each week or should I accept a job that offers $20 per hour but no benefits? Since most of my students like the idea of making money, many students became involved in their own learning and were able to identify the point of intersection, and a few of them even started developing graphical interpretation skills (e.g. the number of hours worked when both jobs make the same amount of money)! At this point, I was still far more excited about my own course than my students were, many of whom seemed like they might be ready to cautiously buy into the mathematics curriculum.

The few weeks that followed didn't go as smoothly. All the math teachers planned our materials together in our PLC meetings and we all devoted one and a half class period towards teaching each math fluency skill. These fluency skills included using the equal values method, substitution method, and elimination method to solve systems of linear equations. We provided

step by step handouts for each method and modeled how to use our step-by-step guide for each solving method, but students were overwhelmed by the quick pace we were setting. To make matters worse, during the second semester we taught our students how to translate English word problems into mathematical equations for the first time. While this contextual skill is a vital skill and helps our students relate math to everyday familiar situations, we were teaching too many skills all at once. Our assessments on graphing, equal values, substitution, elimination, and word problems proved to us that most of our students were extremely confused and many students became reluctant to try to understand abstract mathematical skills even when teachers helped walk students through complex questions. None of the math teachers knew what to do and none of the math teachers wanted to slow down since we still had many vital skills we hadn't covered yet. When spring break arrived, everyone became so frustrated by the lack of motivation and progress that we decided to move on to our next unit so that teachers and students would have an opportunity to have a fresh start.

The confusion in our classrooms in addition to large numbers of students who are barely passing assessments has shown us that careful planning and clear learning goals and expectation is not always enough. While our instruction has been incremental, my colleagues and I have observed that there are many middle school State Standards and skills that our students did not learn. For example, many of our students have no idea where the y-intercept is, how to graph coordinate points, and other skills math teachers have expected them to know from the very beginning of the school year. When I ask my professional colleagues whether they have strategies for teaching these basic skills, they often tell me that our students should have already been taught those skills and we need to focus on teaching our 9^{th} grade content. As I walk around my room supporting students, I have observed that most of my students do ***not*** know how to

graph coordinate points and many of them are extremely uncertain which axis on the graph is the y-axis. This has made it difficult or my students to identify the starting point and other skills such as identifying the rise over run while graphing has been equally difficult for many students. Seeing all the different foundational skills my students struggle with has led me to believe very strongly that math teachers need to be more careful about allocating enough time towards key review before we move on to new material. Even if we are unable to cover all the essential units, including quadratic equations, it is better to build up our students' mastery and confidence in solving and graphing linear equations than it is to rush and make students feel lost and disenchanted with mathematics. While we often try to overlook old skills in the hopes that students will suddenly remember those skills and be ready to move on, this does nothing to aid our goal of creating a generation filled with independent math thinkers and doers.

When I started teaching in early February, in my observations and assessments of my students, I also noticed that students were prone to combine variable terms (e.g. +3x) with numbers (e.g. +4) and make other fundamental mistakes that showed they understood very little of the symbolic language math teachers had tried to instruct them in during the first semester. It therefore became very apparent to me that students needed a context to understand why mathematical equations and graphs are relevant and valuable in their lives. For example, instead of simply asking students to solve $3a + 4 = 10$, I could also provide an accompanying context such as buying 3 apples and getting $4 back in exchange for handing the cashier a $10 bill. This would help students understand that to discover the cost of the apples, I would first need to discover the amount of money I paid for 3 apples. Providing context is essential for allowing students to make the connections they need to understand mathematical language in the first place. When students have real-life examples they can relate to, this enables them to make

meaning from algebraic language, tables, and graphs. Therefore, making math relevant and valuable to my students also ties in with my goal of making their learning experience smoother and more intuitive.

While my goals of creating a positive and smooth learning environment were fairly straightforward, finding a way to follow through with my goals was a much more complex dilemma. My students were already discouraged from the first semester, in which many barely passed algebra and many more didn't pass. My greatest dilemma, however, is that my mentor teacher and algebra colleagues all felt we needed to cover a multitude of concepts and skills we never got to during the first semester. These included abstract skills such as solving and graphing systems of equations, solving and graphing one variable and two variable inequalities, solving and graphing exponential equations, and factoring, solving, and graphing quadratic equations. Given that our students have multiple misconceptions and gaps in understanding, the rapid pace that algebra teachers feel pressured to teach all these skills is not conducive to allocating sufficient time for our students to engage in essential explorative activities that will help them relate to and make meaningful connections with mathematical language. My top priority as a math teacher is to provide students with carefully designed activities that allow them to explore math problems in contexts that they can identify with and relate to. Unfortunately, given our time constraints during our second semester and the pressure my colleagues felt to cover a large variety of mathematical concepts and skills, the amount of time allocated towards each unit was insufficient for creating contextual activities that gave students enough time to explore and make sense of each mathematical concept and skill. The constant pressure to move on to new concepts and skills gave my students and I insufficient time to engage in contextual activities that would help create a smooth and positive learning atmosphere in my classroom.

Journaling Themes

In my recent journaling I discovered a key mistake that we were making both in the first semester and in the second semester. During our first semester we chose not to provide a targeted review of key middle school concepts our students needed to be successful in 9^{th} grade algebra. While math teachers at my school were confident that with enough practice activities our students would catch on to our material, the result was far worse than any of us expected. Our students were so cognitively overloaded, that very little learning occurred during that first semester despite all our thoughtful discussions, step by step guides, clear learning targets and rubrics, and our expectations of what we expected our students to know at the end of each unit. This mistake was repeated during our second semester. Since we spent a lot of extra time trying to teach our students basic solving skills (e.g. $3x + 5 = 2x – 8$) and graphing linear equations, this left us feeling rushed right from the beginning of the second semester. It felt like we had spent ½ the school year trying to teach ¼ of the material and assessments. Math teachers now felt pressured to teach the remaining ¾ of the concepts and skills from our College Preparatory Mathematics (CPM) curriculum in the remaining ½ school year we had with our students. To make matters worse, math teachers felt like they had tried everything for the first few units and none of our step-by-step handouts, guides, practice activities, or anything else helped our students build those key early foundational skills. This meant that our classrooms were filled with unmotivated students. A couple of my caring colleagues even confided in me how frustrated they were that they had some students that refused their one-on-one help since these students stated that they weren't going to get it anyway. In the beginning of the school year our classrooms were filled with unconfident students with an insufficient foundation in mathematical

thought and the learning atmosphere didn't appear to be improving.

One of the most important things I have realized while journaling and reading research is that a growth mindset is probably the most important aspect in determining the success of our students. Unfortunately, many algebra teachers feel pressured to launch into algebraic exploration and much less time is allocated towards providing real-life examples our students can relate to and value. There are two large reasons that limited our time to focus on how and why we use mathematics in solving real-life problems. One of these reasons is that math teachers in my high school feel pressured to follow the College Preparatory Mathematics (CPM) curriculum and while our CPM algebra textbook does have a few contextual activities, many of the mathematical language practices early in the book are too abstract and language-packed for our students. To put it concisely, our book cognitively overloads our students and my colleagues felt pressured to follow this book. Whenever I asked if we could create a lot of our own activities, I was cautioned that we shouldn't veer too much away from the book because our district wants us to follow this curriculum. The second large reason for my colleagues and I not being able to create classrooms filled with motivated and determined students is many of our students have large gaps in foundational skills they need to make math the smooth experience it otherwise could be. Early in the school year our students were required to take an I-Ready assessment. The majority of my colleagues' students assessed at the 3rd-6th grade level. Given that we are required to teach a fast-paced 9th grade curriculum, this poses the questions, "How do we make up 3-6 years of academic material that our kids need to tackle the new material? How much time should we spend reviewing when we have so much material our students will need in their 10th and 11th grade classes with us?" These pressures are what has inspired my colleagues to believe we need to review as we go and carefully build a foundation of 9th grade skills that we

have been instructed by our district to teach.

With the pressure to introduce and build upon high school level abstract mathematics thinking, solving, and graphing skills, we continued to set a steady pace during the second semester. While this pace seemed slow to my colleagues and I, I observed that most of our students couldn't keep up with all the concepts and ideas we were teaching them. Some of our students needed extra time to discuss and practice the material, while other students needed to make up days of school that they had missed. My colleagues and I continued to meet several times each week and we all continued to try our hardest to create step-by-step guides and practice problems for our students to tackle solving and graphing systems of equations. I continued to observe many math teachers and have increasingly adapted teaching strategies such as using short easy-to-understand learning targets, sentence stems, summaries, and clever phrasing that helps students translanguage from English to math. For example, in the exponential unit, which was the unit most of my journaling occurred in, one teacher taught their students that when changing 110% to a decimal, the word percent could be broken down into two parts. The first part, per, in mathematics and science means to divide, while the second part cent means 100. This math colleague then gave valuable contextual examples our kids can relate to including that there are 100 cents in a dollar and 100 years in a century. I am always eagerly adding these strategies to my arsenal to try to make the learning experience smooth and relatable. My colleagues and I cherish our victories and while we often struggle to find quick ways to introduce contextual relatable examples for our students, there are times we succeed spectacularly as well, and the exponential unit was by far the most successful unit we have taught this school year.

While the exponential unit, which was packed with contextual and relevant materials, went well, the other units didn't go nearly as smoothly both for me and my colleagues. While we

did provide valuable and relevant word problems throughout our system of equations unit, we simultaneously rushed through graphing, equal values, substitution, and elimination skills, which are all abstract procedural skills our students struggle with. In our Professional Learning Community meetings and other shared discussion and planning times, I was happy to see that we were making a lot more effort in the second semester to tie in relevant context, but unfortunately the pace we felt we needed to set was far faster than our students could manage. Our classrooms remained discouraged and many of our students eagerly waited for the bell. This second semester served as a great learning experience for me. Having great word problems relating to volleyball, anime, pizza, and other topics isn't enough. Combining that with step-by-step guides, thoughtful modeling and phrasing, and small group practice activities is also often not enough for most of our students. The number one conundrum I was having is my kids had no idea how to translate my real-life word problems into mathematics. I was always careful to use contexts they enjoyed, which I knew from a survey I had given them when I started the class, and I always kept my wording as simple as possible, but during the first semester teachers used word problems extremely rarely and to my students, translating word problems into math was a daunting task. Providing context is essential since it gives students a chance to relate to, understand, and appreciate mathematics, but students also need a chance to learn how to translate English word problems into mathematical language without concurrently having to learn a slew of other challenging mathematical skills.

During the system of equations unit, I used highlighting and other notetaking techniques to emphasize key pieces of information my students needed to know to translate between word problems and mathematical symbolic language. For example, I explicitly taught my students that words such as is and are mean = in mathematics. While I believe our explicit notes and

highlighting would have been helpful had we only been focusing on translating word problems, my mentor teacher and colleagues insisted that we focus on mathematical fluency skills such as equal values method, substitution method, and elimination method. At their insistence, I simultaneously introduced word problem translating skills while also embedding new abstract solving techniques into every single class. While I tried my best to teach my students how to use the step-by-step guides we had created for them, the constant switch between using equal values solving technique one day and using substitution method the next was causing my students heads to spin rapidly. Our assessments clearly showed that our students were confused and lost, but my colleagues still felt rushed by our CPM curriculum textbook, and they believed that our students would catch on to all these math fluency skills as we continued to practice them. Being a novice teacher, I continued to set the same fast pace as my colleagues, introducing new content almost every single day. Unfortunately, by the end of the unit, our students' performance only got worse, students were discouraged and unmotivated, and teachers were even more frustrated by the lack of motivation we were seeing in our kids. This made it very clear to me that to prevent our students from being cognitively overloaded, we need to focus on teaching them one major skill at a time. Therefore, in addition to embedding relevant and valuable contextual examples into our curriculum, we also need to set a reasonable pace, and this means that teaching our kids to translate word problems needs to happen before we introduce other concepts and skills.

In addition to providing our students a gateway to travel between reading, writing, and thinking in English to interacting with mathematical language in the same ways, we also need to give our students time to explore and reflect for themselves. The pace to cover the numerous math procedural skills in our districts' College Preparatory Mathematics curriculum leads many teachers to feel they don't have any extra time to have kids explore for themselves, interact with

patterns, and make their own conclusions. While I agree it is important to provide key notes and guides to get kids started in how to think and write like a mathematician, we also need to give them time to play with patterns of numbers and to discuss and describe with each other the pattern they are seeing. Students also need time to explore and reflect upon each concept and skill and why mathematics is important in their lives. Giving students this extra time to explore and try to think for themselves would not only help boost their confidence, but it would also give them a sense of independence. Giving students extra time to explore each concept will also help all our kids extra processing time. Many kids who struggle the most in math classes desperately need this extra time to reflect, explore, and process what everything means and why it is important. Additionally, additional time to reflect and explore will also enable our high achievers to have a chance to teach their peers and in doing so reinforce the knowledge at a deeper level themselves. Even if a less rapid pace led to math teachers being unable to cover all mathematical concepts and skills, our students could for the first time in their lives feel like masters in some of those skills. This would not only boost their self-efficacy in mathematics, promoting that critical growth mindset we need in our classrooms, but the key foundational skills they would have mastered has the potential for making future units go more smoothly as well. Giving students time to achieve greater mastery in mathematical thinking would also boost the morale of my student groups, which would further benefit my students in their future interactions with one another.

Journaling Conclusions

The irony of life and of mathematics is sometimes to move forward effectively, you first need to take a step back. Our exponential unit largely started on a positive note throughout all

our algebra classrooms, not just because we chose to use rich contextual examples our kids could relate to and value, which in itself was extremely important, but also because we took extra time to review linear equations and compare and contrast them to exponential equations. This essential review is often either neglected or rushed at speeds that are not conducive to learning. In the former case, students can't relate to the new math language and skills because they don't have the language foundations required to do so and the latter case usually turns out even worse since students have just enough time to recognize material they have seen, but despite this they don't have enough time to understand why what they are seeing is important or how they should process the information. A rushed review followed by new material often leads students to tell math teachers, "I am just not good at math" or "I'm not going to get it" or even more frequently we'll be met be an ominous silence and lack of motivation. Since no teacher wants this horrifying situation to happen to them, especially not right after the depressing pandemic shutdowns, we need to recognize the importance of review and a focus on rich contextual examples such as making activities on investment and other real-life topics our kids can value and engage with! The exponential unit was filled with fun and optimistic ways to make math a tool to improve our lives and so should all the other units of key concepts and skills.

Ensuring students have a strong foundation of relevant skills is even more important when abstract and flexible math fluency skills are being taught. I have seen numerous students flounder when confronted with using highly abstract procedural skills such as equal values method, substitution method, and elimination method. Manipulating variables, even when only one equation is involved, is very challenging and combining aspects of two equations at the same time sends many of our students into a state of complete confusion. To avoid this, we need to provide rich contexts and word problems for understanding single equations right from the

beginning of the school year. While the temptation to focus exclusively on mathematical language (e.g. $5x + 3 = 6x + 7$) still pervades large sections of our math textbooks and many of our classrooms, this practice needs to stop. A focus on math language alone, is not only unbalanced, but it is unintelligible for our students. We need to start math courses with relatable experiences that inspire our students to say, "I get this!" and "Huh! Math *is* in everything we do. My teacher kept telling me math is in real life, but I never believed him/her!" A strong foundation in translating relevant word problems into mathematical language is the first step towards raising a generation of adults that use math to make wiser choices and improve their lives.

One other thing I learned early in the school year is that students get intimidated whenever they see x's, y's, or other variables being combined with numbers. Therefore, I believe that when we first teach basic examples of using variables, we need to give students a context that those variables could represent (e.g. apples, hours traveled). Going one step further, we should also provide physical objects students can see, touch, and feel. Many students cannot relate to x's and y's, but when I tell students that 3 apples cost $3, show them that mathematically this is written as $3a = 3$, *and* on top of all that we also physically show them 3 apples and have them role-play giving us $3 (e.g. monopoly money) for those apples, then the impression they have of mathematics being, "only for smart people" might finally change! Many teachers are resistant to or even unwilling to turn our abstract art into such basic elementary school level examples, but several kids need to see and feel the basics they are used to before they can move on to increasingly complex plains of thinking.

Differentiating to make math a smooth and fun experience means kids need to feel like champions and they need to feel like the things they value are being prized. While I have

surveyed my kids to see what sports, TV shows, other activities, animals, and occupations they like and are interested in, I need to always expand my knowledge of my students' interests, cultures, and values. This became crystal clear to me recently in a math class I was supporting when a student added 3x + 4 and made it 7x. I asked him whether 3 apples and $4 could be added to be 7 apples. This student quickly told me in a mix of exasperation and playfulness, "Why apples again?!" When I asked him, "What's wrong with apples?", he told me, "I am getting bored of apples. And, you ***always*** use apples when I do something stupid!" I quickly suggested changing the context to oranges, a fruit he apparently didn't especially like, and we soon decided to make them pears. Anyway, this little somewhat playful exchange made me realize that while I knew a lot of my kids like pizza, burritos, and similar common staples of society, I have no idea what other foods I can mix into my class to create a more flavorful and original environment that will keep all my kids engaged. Also, I don't want my students to associate apples with stupid mistakes! Therefore, differentiating not only means including relevant examples my kids can relate to, but also embedding my math problems with a huge variety of things such as volleyballs, basketballs, pears, giraffes, and hours worked as a nail technician. While I have always used a wide variety of contexts for the math problems I create for whole class discussion, I now have also created and used an increased array of questions for my more personalized discussions with individuals and small groups.

Supervisor and Mentor Teacher Feedback

In addition to observing three other algebra teachers, I have also had the opportunity to receive feedback from my mentor teacher and supervisor. These sources of feedback have also helped me learn what I need to do to create a smooth and positive experience for all my students.

My mentor teacher has shown me how to make step-by-step guides to help my students learn new skills, math sentence stems to help reduce my students' cognitive load, and how to utilize the whiteboards we have around our room to help motivate kids to work together to solve abstract mathematics problems. He has also advised me on other strategies I can used to keep my students engaged. For example, in whole class discussions, he taught me that often it is necessary to match my students' energy by asking various students questions at a rapid pace. Since motivation hasn't been very high in most of the algebra classes at my high school, we spend a lot of time in whole class discussions trying to get kids to understand enough of the essentials so that they can tackle short, small group practice activities we give them at the end of each class. Therefore, rapid questioning is a good way to get everyone involved in learning and teaching us these essential pieces of knowledge before teaching it again to their teammates in small group math fluency practice activities. Additionally, my mentor teacher and other teachers I have observed have taught me the importance of having quick 1 minute think-pair-share activities to discuss key concepts and skills we present to them during whole class discussions. Making fill in the blank sentence stem summaries also gives students a chance to use their guides and notes to describe and reinforce key ideas they need to know in each unit. All of these strategies are essential for giving students the confidence they need to tackle similar questions in their small groups.

My mentor teacher and supervisor have also given me invaluable advice on how to conduct successful whole class discussion and small group activities. They both realize that motivation in math classrooms isn't very high now, especially after the pandemic shutdowns, and they encourage me to move around the room and be especially active near off-task groups. My supervisor has emphasized the importance of correcting disruptive behavior as unobtrusively

as possible. For example, instead of instructing students across the room to try to stay focused and participate in the discussion, and in doing so draw even more attention to them, I should instead stand right next to them, showing them that I am aware that they aren't focused, and making my presence stronger and more pervasive. In this way, I quietly correct their behavior and help guide them to staying on task. Other discreet strategies such as holding eye contact for several seconds can also be helpful in reminding students to pay attention without drawing attention away from my teaching.

In addition to always moving around and actively keeping students focused and supporting them in tackling math concepts and skills, I need to always be aware of what is happening throughout my classroom. In an environment with a lot of teenagers that have many preferences higher on their list than learning mathematics, that means I need to provide quick and helpful support for one group of students and then move on to support another group in staying on task and helping them tackle math concepts and skills. Since normally I have six groups of students attending each class day, my supervisor also advised me that when multiple groups are struggling with a particular concept or skill, I can call up one member from each group, teach them all at once how to tackle the question, and then have them return to their groups and teach their groups how to successfully confront the same mathematical thinking and skills. Teaching their peers will reinforce their own learning while also giving their peers another chance to see how to think about and solve complex math problems.

My mentor teacher also instructed me how I can utilize other valuable strategies to reinforce the knowledge of all my student groups and ensure that my small groups have the essential knowledge they need to succeed. One particularly useful strategy that helps reinforce skills of a member of each group is to tell them that you are going to give them a minute to look

through their notes and when you come back to them, you expect them to tell you how to tackle a key element of a math problem. This both helps students practice using their interactive notebooks (e.g. table of contents, vocabulary section, and key step-by-step and other guides) and it also helps them realize that when they utilize their resources, they can succeed all on their own. While my mentor teacher, colleagues, and I have not succeeded in teaching our students to be independent, by using this form of guidance we are teaching our students how to use their notes to be more successful and organized and they are slowly piecing together all the skills they need in math to be master mathematicians. There are many strategies I can use to support varying learning styles and I continue to work on improving my ability to assist students with a wide range of skills.

There are a vast array of strategies and supportive guides that my colleagues and I use to teach our students to learn essential mathematical thinking, reading, and writing skills. By using all these skills, I support a wide range of learning styles and help boost my students' confidence in tackling the foreign language they know to be mathematics. Learning a new language, especially such an abstract one is not easy, and my constant reflections along with the guidance I receive from experienced teachers has helped me adapt my teaching style and provide a structured and supportive environment for all my students. Additionally, I am always coming up with fun real-life problems to help show my students that math isn't just an isolated tool we use in classrooms, but instead a language that can be applied to almost every aspect of our lives. Going forward I will continue to improve myself as a teacher and implement more and more techniques that will help make my students' experiences in math smoother and more fun!

CHAPTER 5

DISCUSSION

Going Forward

Mathematics has a reputation for being one of the most difficult skills to master. This is not surprising when mathematics at its very core is not just a set of abstract concepts and skills but is an entire language. Mathematics is a language that involved very condensed and symbolic sentences, graphs, and other visual representations. The cognitive overload that many of our students experience in numerous mathematics classrooms makes it clear that we need to urgently change the way we instruct mathematics to meet the needs of all our students. My goal has always been to provide my students with a positive and straightforward learning experience. I want to reach all my kids and to do this I am always finding new strategies to teach. During my action research I developed skills to help my students organize their learning and make their learning experience smoother. The skills I learned include making step-by-step guides, clear learning targets and grading rubrics, key vocabulary notes, handouts with sentence stems and mostly solved examples of math concepts and skills, and summaries of essential knowledge. I also learned to use rapid questioning in whole class discussions to get my students actively engaged in early introduction phases of concepts and skills. After this key introduction phase of scaffolding essential knowledge, my students were given opportunities to practice these new concepts and skills in their small groups. Since motivation isn't always high, I always hopped from group to group helping to remind students how to tackle various challenges. I also tried to remind students to stay on task as unobtrusively as possible and reminded them that with practice they would get increasingly proficient at understanding and applying mathematics language and

skills. This was especially important because many of my students had already failed or barely passed algebra during their first semester, and I wanted them to know that when they put in the effort, I would also do my part in ensuring they were fully proficient in mathematics and ready to tackle challenges in future math courses and in life. In every way I possibly could, I tried to make my students' experiences as smooth and positive as possible.

Background of and Limitations of Action Research

I have worked at two high schools and interacted with over a dozen math teachers, and I can say with certainty that every teacher I have worked with wants to do everything they can to help their students succeed. In teaching mathematics, however, there are two prevailing philosophies on how to provide the optimal learning experience and build on students' knowledge. Since math is a language of numbers and symbols, many math teachers believe that early in the school year we should exclusively focus on teaching our kids how to analyze and interpret patterns in numbers. These teachers believe that simultaneously giving a context to these numbers will cognitively overload our students even further. Unlike many of my colleagues I believe that giving a simple context early on, such as relating total income to number of hours worked (e.g. $10 after one hour, $20 after two hours, etc.), would help my students succeed. By using a simple context my students can relate to while simultaneously focusing on the pattern (e.g. pattern is growing by $10 per hour), I could help many students understand why the rate of growth (e.g. hourly wage) and other mathematical structural components of equations and graphs are relevant and valuable in their lives. While I believe this contextual foundation is essential and is supported by the research, implementing context into my classroom while simultaneously teaching a multitude of skills proved to be difficult. I believe

that had I been given the opportunity to start my action research in the beginning of the school year, when the pace of new concepts and skills was much slower, I would have reached a lot more students. Relating numbers to money and other relatable real-life contexts has assisted many students in making sense of the numbers and symbols they are seeing. Unfortunately, the research for how best to organize real-life examples for an entire course is unclear and therefore many teachers feel it is safer to follow the textbooks, which our students also have access to.

During my action research, my colleagues and I shared our concerns for the low motivation and achievement in our classrooms. The pandemic school shutdowns and other ramifications caused by Covid-19 clearly had large consequences for our students. Not only were teachers surprised by the large gaps in our students' mathematical knowledge, but many students struggled to socially reintegrate with their peers after over a year of distance learning, a short return, and then summer break after that. In the early stages of the 2021-2022 school year, in which students readjusted back to normal school life, we simultaneously supported our students' social and emotional well-being, while also trying to help them establish key algebraic thinking, reading, and writing skills. This tested both teachers and students in new ways and in many ways things didn't go as smoothly as we would have liked. Ultimately, while we all tried to support a growth mindset in all our students, our attendance rates weren't as high as we'd have liked and many students who did come to class frequently zoned out or became distracted by their phones or their peers. Therefore, when I took over teaching in February of 2022, most of our students were not academically at the same level that students would have been before the pandemic. While the decision to move on to new material during the second semester weighed heavily on my colleagues' minds since we all knew they weren't ready, my colleagues also wanted to build all of the essential foundations our students would need in later courses and we knew most of our

students were frustrated by the linear equation writing and linear graphing skills we had focused on throughout the first semester. We therefore continued with our curriculum, hoping all the rich materials we had made for systems of equations would inspire our students to become more involved in their own learning.

The first unit I taught my students was systems of linear equations. The systems of linear equations unit requires that students can represent two or more linear patterns using tables, equations, and graphs. Since students were still struggling greatly to represent one linear equation or graph, continuing with this traditional unit posed major concerns for me. While I understood my colleague's intention to prepare our students for higher-level mathematics courses and I also understood that no one wanted to continue the same unproductive struggles we had undergone the first semester, the choice of simultaneously introducing context to students while having them interpret two abstract representations at the same time, was not a choice I would have made. Instead of rushing to ensure we covered the entire textbook curriculum to already discouraged students, I believe we needed to spend time tying patterns of numbers to real contexts our kids could relate to. While we did tie in a few contexts at the end of the first semester, assessments clearly showed that devoting 3 or 4 hours to this vital pursuit was not sufficient time for many of our kids to have any idea of what was going on. Therefore, a major limitation of my action research was starting my action research halfway through our first school year coming back from a pandemic and school closures. Systems of equations is a traditional unit in algebra classrooms but given that most of the students at my high school were still extremely confused by thinking, reading, and writing one linear equation or graph, this unit did not go well for me or any of my colleagues.

A common expression in our society is it is very important to start off on the right foot.

Making a good impression is an important step towards getting kids to buy in and the linear units did not accomplish this. Luckily, the exponential equation unit that followed gave me a fresh start and using rich contexts such as investment and even relating exponential growth to Covid-19 allowed me to finally receive some of the buy in that is so desperately needed in our algebra classrooms. During the few weeks we covered exponential equations, graphing, and interpretation skills, I provided many rich contexts and several of my students went from being completely unmotivated to becoming engaged and interested by the material. Seeing the positive results of this new material really makes me wonder how my action research will go in the future when I have my own classroom and can spend an entire school year showing my kids that mathematical thinking, reading, and writing skills can be applied to almost all aspects of the world we live in! While the first couple weeks of my action research didn't go very smoothly, the remaining month showed me that my continued action research in the future will help me become a much more engaging and interesting teacher. I am more than willing to try new things, veer away from the textbook, and do whatever I can to show my students that math is valuable and relevant in their lives. Giving my students a good impression of mathematics is an essential first step towards teaching them all the intricacies of mathematical thinking, reading, and writing.

Conclusion

While my math colleagues taught me a several strategies for breaking mathematics into clearer and easier steps, which is invaluable in teaching mathematical language, we need to do a much better job of providing contexts our students can relate to early on. The one downfall of my internship as a teacher was we did a poor job of motivating our students and showing them that math is relevant and valuable in their lives. Whenever I hear a student say, "Why would I ever

use this?" or "Math is only for smart people" I wince. These statements combined with the poor attendance and disengagement I see in many of the math classes I observed are clear signs that our textbook curriculum in mathematics is far from perfect and math teachers need to do a better job of clearly showing our students why math is relevant to them. Simple examples such as hourly wages and exponential growth of Covid-19 can help give students vital opportunities to think about and discuss math in meaningful ways. Our students do not think in x's and y's, so why are we starting to teach mathematics in this way? While interpreting the x-axis and y-axis is important, we first need to take a step back and give our students a chance to gradually ease themselves into the language we cherish so much. The pandemic makes this need even more urgent. With so many students having loved ones and friends affected by the pandemic and having their own lives drastically interrupted by this same pandemic, we need to focus on creating a more engaging and relevant mathematics curriculum. The need for this has been around for decades and yet the resistance to move away from relying almost exclusively on traditional textbooks and create a better curriculum has become even more urgent than before. Creating a classroom filled with motivated students who want to learn and grow should be our number one priority and this needs to start right at the beginning of the school year.

The success that my colleagues had during the exponential unit should instruct all of us of the importance of having context-rich materials. Almost all aspects of the exponential unit were filled with rich learning materials and assessments. I am determined to spend time this summer designing and modeling earlier units off the exponential unit. Students can be successful and buy in if we give them every resource they need to do so. Serving under experienced teachers has shown me the importance of creating clear learning targets and grading rubrics, key vocabulary notes and step-by-step guides, sentence stems and summaries, and helpful grouping

strategies that enable students to support one another in discussion of essential and other thought-provoking questions we pose at them. Combining all these skills with a rich context will enable me to continue to grow alongside my students. In the coming school years, I intend to ensure that my students become teachers and that I always remain a student. We are always growing, no matter what roles we are playing, and my students need to see that the adventures of discovering new possibilities and probing for new ideas and ways of thinking does not have to be a scary and unwelcome prospect, but instead should be a realm of beautiful opportunities.

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