MATH ANXIETY AND GROWTH MINDSET: BUILDING TEACHER EFFICACY

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Math Anxiety and Growth Mindset: Building Teacher Efficacy

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Abstract

For many students, math is seen as an anxiety-inducing performance subject; their role in math class is to get as many answers correct as possible. Many students enter the education profession and become teachers. Can teachers successfully manage their anxiety and let go of their preconceived notions about themselves as learners? Through a semi-formal interview process, research explored teacher management of math anxiety and teaching growth mindset in math education; as well as anxieties about teaching mathematics to investigate the impacts anxiety has on growth mindset, efficacy, and confidence in teachers. Further, what mathematics practices and strategies that in turn, will impact the mathematical mindsets that teachers and students alike have about themselves as learners. The research in this paper suggests that teachers who gradually let go of traditional teaching practices and allow themselves to learn alongside their students; to allow mistakes and show students how to learn through mistake-making, can alter their own mindsets about math. A change in teacher identity may impact the mathematical mindsets that students have about themselves as learners.

Keywords: teacher math anxiety, math learning, teacher efficacy, growth mindset, agency

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Introduction

My interest in math anxiety comes from my experience as a math student. I liked mathematics and did well in early elementary math, therefore I thought I had an acceptable level of proficiency in the subject. I felt good about my ability to skip count, add and subtract, follow procedures, and memorize multiplication tables. However, during my time in junior high and high school, I realized that I was not as quick at answering questions as my peers and understanding didn't seem to come as easy for me as it did for my classmates. The procedures taught to me in isolated steps, methods, and sequences left me deflated and confused.

My junior high math teachers had instilled a mindset within me that I was not a "math person." I decided that I could not do math. My fixed mindset towards math meant that I had to take all of my high school math courses twice. I did not receive a grade higher than 60%. In college, I took one mandatory math class and had the good fortune to learn under a professor that appreciated the art and beauty of mathematics as much as the science. I started to think about mathematics differently because I was introduced to diverse ways of knowing and learning. We played math games and used Cuisenaire rods, dice, playing cards, and other manipulatives to connect isolated methods to concepts for deeper understanding. My identity as a math learner started to shift.

Although there are disciplines in mathematics that I do not fully understand, I now see myself as a pupil of mathematics, open to active learning alongside my students as we build efficacy with one another. I see myself in struggling math students. As an educator with math anxiety, my research situated me with other math-anxious educators

who discussed strategies to help struggling students overcome a fixed mindset and manage their math anxiety in the classroom.

Research Aims and Objectives

As a conceptual framework, traditional classroom delivery methods of mathematics guided my inquiry. The purpose of my research was to explore Alberta teachers' experiences with math anxiety, growth mindset and teacher self-efficacy and inquire into how it influenced the way they taught math in the classroom. What sort of impact does math anxiety have on growth mindset, efficacy, and confidence in teachers at the local level?

Traditional instruction emphasizes the use of algorithms, drills, memorization and a view of answers as either right or wrong. If a student gets an answer wrong often the response is more drill and practice. This pedagogy has left many students with math anxiety and the fixed mindset that they "can't do math" (Boaler, 2013). For students that are frequently getting wrong answers to closed questions (only one right answer), it is hard to think that greater achievement is possible with more effort (p.146).

Alberta teachers face conflicting perspectives on the way to teach mathematics and develop mathematically proficient students (Khalaf & Zin, 2018). Stakeholders support divergent viewpoints that often clash with one another and parents, media, politicians, and others question the methods that teachers use to develop numeracy skills. Even when pre-service teachers learn about new teaching methods through university, many revert to comfortable (traditional) teaching approaches, and minimal change happens (Gainsburg, 2012).

Scientific evidence demonstrates both the incredible potential of the brain to grow and change and the powerful impact of growth mindset messages upon students' attainment (Boaler, 2013). The fixed mindset that only certain people will be "mathematics people" needs to be challenged in my context. As a numeracy lead teacher, I have the opportunity to listen to teacher's stories about their past math experiences as students and now as a teachers. Often their experiences as students influenced their pedagogy; teachers with negative math experiences avoid approaching numeracy in different ways because they see themselves as inadequate mathematicians. A teacher with a perceived lack of usable knowledge may mean they are more confident with a traditional approach; showing students' steps and procedures to get answers instead of teaching strategies and number sense because that is how they learned mathematics as a student in the classroom. My intent in researching anxiety and teacher efficacy in mathematics is to examine how math-anxious teachers manage their anxiety and teach growth mindset in math education.

My research will continue my story as a teacher with math anxiety who has learned to manage it in ways that help students struggling with theirs. I am fortunate to have colleagues who have chosen to come alongside and support me in my math journey. Together we're learning to detach ourselves from the ineffective ways we were taught and embrace more progressive approaches to teaching mathematics. I want to help other teachers do the same. I intend to use the knowledge gained through research to further my own efficacy, and provide collegial support in my role as a math lead teacher to the teachers in my school.

Related Literature

Math Anxiety

Math anxiety develops because of the way math is presented to students (Finlayson, 2014). Beilock and Willingham (2014) state that math-anxious people experience tension, apprehension, and fear of many situations related to mathematics. Math-anxious students often arrive at school with a fear of math instilled in them by their parents (Krpan, 2018). Teaching mathematical tasks in a procedural fashion in which students are compliant recipients of concepts and practices is still common today (NCTM, 2014). The same research findings regarding math anxiety in students can also be applied to teachers. This is supported by my own experiences and the experiences of the educators who participated in the research.

This issue presents a challenge to researchers, as understandably, educators are reluctant to admit they have math anxiety out of fear they may face judgement from their colleagues (Krpan, 2018). Elementary school teachers who have participated in research studies report having high math anxiety and expressed concern that it hindered student performance in their classrooms (Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018). Math anxious teachers often adopt a traditional delivery method because they feel more comfortable with this approach (Finlayson, 2014). Their perceived limitations take away the confidence needed to seek out alternative teaching methods.

Math-anxious teachers may unconsciously promote math anxiety in their classrooms; a condition they are trying to manage in themselves. According to Khalaf and Zin (2018), traditional teaching methods offer a superficial learning approach based on direct instruction and memorized knowledge with little time for questioning the

process to ensure deeper conceptual understanding for students. Knowledge of procedures does not necessarily equate to conceptual understanding; students can divide fractions without understanding the procedure and why it works (Wiggins, 2014). Knowledge of procedures and concepts is the desirable outcome. Students who view the classroom as a place to develop conceptual understanding instead of memorization report more adaptive reasoning strategies (Young, 1997).

Taken as a whole, research on mathematics teaching and learning suggests that mathematics is far more than finding an answer; reasoning and explaining procedures and their relationship to concepts are fundamental aspects of mathematics.

Growth Mindset

Carol Dweck (2006) argues that students' mindsets influence whether they will adopt a positive or negative outlook when it comes to learning goals, and how hard they will strive to reach them. Dweck (2006) states that mindsets impact many aspects of children's lives, including sports and academic success. A child's mindset develops as they begin to interact with the world around them. A young students' mindset is shaped as they interact with parents, teachers, and coaches, who themselves have either a fixed or growth mindset (Dweck, 2006). Boaler (2013) states that divisive and deeply-held beliefs about learning, and about what it means to be 'smart', are very difficult to change; "Fixed mindset beliefs contribute to inequalities in education; they also contribute to overall low achievement and participation. Schools should be encouraging growth mindset beliefs as a matter of urgency (p. 150)." Mindsets are critically important because they lead to different learning behaviors, which in turn create different learning outcomes (Boaler & Selling, 2017). (Blackwell, Trześniewski, and Dweck, 2007)

followed grade seven students for two years and were able to demonstrate that students with a growth mindset demonstrated continuous improvement in achievement, whereas those with a fixed mindset stayed constant.

I have found that choosing a growth mindset has improved my pedagogy and allowed me to enable students to have a more positive relationship with math. We all need to think mathematically throughout our lifetimes because when we journey through life afraid of math, we get constant reminders that we are always wrong (Boaler, 2017).

Teacher Self-Efficacy

Teachers who believe they have the ability to influence student learning and achievement positively are more willing to implement challenging strategies to achieve their goals with students (Bruce & Ross, 2008). Teacher self-efficacy (Bandura, 1997) will have an important impact on the quality of learning students experience in the classroom. According to Bandura, "People fear and tend to avoid threatening situations they believe exceed their coping skills, whereas they get involved in activities and behave assuredly when they judge themselves capable of handling situations that would otherwise be intimidating (p. 194)." Teachers with a sense of low self-efficacy in mathematics teaching may avoid professional development programs or choose not to take part in peer coaching opportunities because they believe it will not benefit them. Bandura (1997) emphasized that self-efficacy is a critical factor in whether or not students achieve. Teacher self-efficacy has a major impact on the quality of learning students will experience; students learn much more from teachers with a high sense of self-efficacy than those plagued by self-doubts (Santrock, 2018). Santrock stated that teachers with low-efficacy lack the confidence in classroom management, become

stressed and angered at misbehaviour, have low expectations when it comes to student improvement, feel trapped in their jobs, often resort to punitive discipline, and regret their choice of professions. Clearly efficacious teachers enjoy a better sense of overall wellness in the classroom, set challenging standards, have high expectations and provide appropriate support for academic achievement. Krpan (2018) explained that there is a reciprocal relationship between student achievement and teacher self-efficacy: as one increases, so does the other. High achievement positively impacts students' self-efficacy. Therefore, student self-efficacy, teacher self-efficacy, and student achievement all influence each other, with positive correlations among them (Krpan, 2018).

Research Methods

I conducted a qualitative research inquiry framed by the questions, "What are Alberta teachers' experiences with math anxiety and a fixed mindset, and how do they believe these experiences influence their sense of self-efficacy in the mathematics classroom?"

Before beginning the data collection phase of the study, I followed the regulatory frameworks established by the Research Ethics Board of Concordia University of Edmonton. Written permissions to conduct the research was obtained through the school board and local principals prior to commencement of the research. Once written consent was granted by the superintendent and principals, information and consent forms were distributed to participants. Participants who expressed interest in the study had an opportunity to ask questions via personal email about the nature of the research prior to signing the consent form. Participants were not identified to the superintendent or principals and remained anonymous throughout the study. I contacted the participants via

private email to confirm their participation before interviews were arranged. Interviews between the researcher and participant were conducted at a mutually agreed upon location. Three teachers from different schools in central Alberta were selected who had a minimum of five years of mathematics teaching experience. Participants were free to withdraw from the study at any time. For the purposes of this study, pseudonyms (Agnes, Beth, Cathy) were assigned to the participants to protect their identity and make it easier for the reader to track the comments of all three participants.

Data Collection

Data Collection was facilitated through one-on-one semi-structured interview of 45 - 60 minutes in duration with each participant. The questions were open-ended, allowing participants to share their stories, and give each person a voice and opportunity to be heard (Parsons, Hewson, Adrian, & Day, 2013). Data was gathered from the following questions, other questions came to mind organically, through conversation that I have not included in the report. Most of the research was anchored by these main questions:

1. How did early student math experiences shape your identity as a math learner?
2. What are your thoughts on the influence a teacher can have on student mindset in regards to mathematics?
3. What are your thoughts about the belief that some students (and teachers) are just “not math people?”
4. What strategies or “best practices” have you incorporated into your pedagogy to help struggling students with mathematics?
5. As a teacher of mathematics, what sort of work (professional development, courses, literature) have you done for yourself to positively impact your identity as a math learner and teacher?

6. How have such experiences impacted your work with students?

The audio of the interviews was recorded using a digital recorder, playback of the recordings allowed me to carefully listen for nuances in the speech such as tone, emotion, and overall engagement with each question. This helped me re-experience the interviews, facilitated transcription and helped to organize my data later on (Parsons, Hewson, Adrian, & Day, 2013). I was able to identify potential themes and found some of the direct quotes to possibly support would-be themes in my research.

During the initial reading of the transcripts and the first cycle of coding, I was able to find accounts in the data that related to childhood experiences with math anxiety and perceived self-efficacy. These words and statements gave me a "sense of the whole" as I read and reread the transcripts. (Creswell, 2015, p. 243). I analyzed each interview to find segments of text that associated to the research question, then assigned a code to describe them (Creswell, 2015). I grouped similar codes into themes based on what was discussed most frequently during the interview process.

It is worth noting that all participants were female. Girls often receive messaging that mathematics is not a subject they should expect to do well in from the early years of school (Boaler, 2014). Although many of my colleagues hold the position that they don't believe the stereotype that girls are not as good as boys in math, individuals can still hold that belief with realizing it. Even if obvious gender bias is declining, as some argue, research shows that unconscious beliefs underlying negative stereotypes continue to influence assumptions about people and behavior (Hill, Corbett, & Rose, 2010.) By high school, girls may avoid more difficult math courses and avoid math-related university programs as the enter post-secondary schools (Boaler, 2014). Cathy told a story about not

entering into a faculty of engineering after high school even though she had received scholarships to do so because of her perceived sense of self-efficacy due to her math anxiety.

The Shape of the Data

The participants represented diverse math backgrounds and levels of mathematical knowledge with various levels of math anxiety. All indicated that they had learned mathematics in a traditional classroom environment and all of the participants were able to recall formative memories or early student experiences that changed the way they saw themselves as math learners. As their confidence in math waned, their anxiety increased, and a negative view of themselves as math learners developed.

Cathy described it as a "downhill spiral" as her confidence in herself slowly eroded:

> "I loved (math) as a kid and then I was very afraid of it and I try and share that with kids now too because it changed the way I went through university. I would've loved to have stayed in math and taken challenges and I even received scholarships to engineering but I didn't take them because I didn't think I could do it."

This story of a perceived personal failure was a clear indicator of the power of a fixed mindset. Science, Technology, Engineering, Arts, and Mathematics (STEAM) initiatives are starting to change the narrative in the classroom. STEAM projects help girls build efficacy with these disciplines at an early age (Boaler, 2014). Cathy continues:

> "If STEAM and those types of things had been around when I was a kid, I wonder if I would have had more confidence and that's why I'm really trying to push our school and push our kids to do those types of activities and to be problem solvers because I really think it opens up doors for them later on."

It is important that students see themselves in equitable learning opportunities designed to instill confidence in many different disciplines so they have the self-assurance to enter into a field of learning they are passionate about.

The changes in teacher practice identified in the research included a shift to a more active as opposed to a passive way of learning: participants taught their students to explain their thinking, ask questions, and embrace mistake-making as part of the learning process. Beth expressed her fear in giving over more control to the students: "It's scary! It's a big change right to--and it's kind of like--you've got to let go of a lot of reins to teach math like that." Her gradual release of control demonstrated her personal growth as a professional.

Mistake-making, discussing failure, and what was learned as a result was an area that all participants felt was an important part of instilling a growth mindset in their students. Beth talked about the importance of building resilient learners in the classroom: "*I think it's important that we make mistakes in front of kids and we point that out to them…they have to learn to be uncomfortable for a while."* It is important for students to realize that working through mistakes won't be easy, but it is a worthwhile process.

The pervasive belief that some people are simply "not math people" was addressed by the participants. Cathy noted that discussions with parents involved shifting the conversation from a fixed belief like, "Well I was bad at math, so no wonder they're

not doing well." To a growth mindset belief such as, "I want you to do your best, and your best might be… 75% but if you're doing your best and you're understanding it, and that's what you're getting, then I'm really proud of you." The participants felt it was very important to help parents unlearn some of their negative self-talk and relearn a more productive, positive language that built student efficacy.

Games are a fun and effective way to teach mathematical thinking, develop computational fluency, and build a deeper understanding of number operations (Rutherford, 2015). Agnes used the word "fun" while discussing her math classes: "We can have so much fun in math if we just let ourselves have fun." Agnes also uses games as an alternative to homework: "You know with young kids, I don't send math homework home, I might send a game to play." When chosen carefully, and scaffolded with purposeful questions, games are an authentic context within which students can develop mathematical reasoning (McFeetors & Palfy, 2017).

Research Findings

Math Anxiety is Variable

All of the participants felt successful at math at certain times in their lives and were able to share stories of failure in math class and how it affected future learning and ambitions. Their lived experience as students shaped their mindset about mathematics. Struggling teachers often feel anxious about math; they question their confidence, and often possess a low self-efficacy in mathematics (Krpan, 2018). When teachers build efficacy by learning teaching practices that move their students toward a deeper understanding of mathematics, it changes their mindset about teaching math. In Beth's words, "I actually started to enjoy teaching math!" Acknowledging fear around

mathematics in front of their students because of past experience is a way the participants were able to identify with learners struggling with anxiety and closed mindsets in the classroom. They work hard to create safe learning environments so students don't feel ashamed or embarrassed about their identities as math learners. When I asked Agnes about how she manages math anxiety in her classroom she said, "We've made it very open, honest, you know, I'll tell my students that sometimes math was hard for me, I'll tell them that, and that's okay." The significance of this acknowledgement coming from a female teacher may give young females permission to talk about their math anxiety without a fear of judgement or disapproval from their teachers. This act of empathy, of identifying with students and their struggles, sends the right message to struggling students and perhaps has a normalizing effect in the classroom.

Professional Development: Moving Forward

When asked about professional development opportunities that moved their practice forward, all participants were able to discuss particular instances that shaped their identities as math learners. Often professional development is expensive and frequently involves bringing in consultants, traveling to seminars, or attending conventions to learn. Cathy stated that the greatest learning opportunities seem to come from working with peers: "...working just with teachers in our district, we have so many experts and so just being able to go in and watch them, really started to change my mind…" Teachers that work together toward a common goal have even greater impact on student outcomes (Hattie, 2016). Hattie (2016) stated that collective teacher efficacy is the single most effective way to impact student achievement in classrooms. Further, it

was apparent that the participants were able to take concepts learned from professional development opportunities and practically apply them in the classroom.

Collegial Support: Room for Improvement

Collegial input has the power to make or break a teacher's self-efficacy. I was pleased to know that colleagues played an important role in the participants mindsets and efficacy. I was surprised to hear about instances of minimal support from peers or positional leaders as participants shared stories of colleagues who did not support them in their efforts to build efficacy in mathematics teaching. Teachers should feel comfortable going to administration or department heads to advocate for the betterment of their teaching practice without feeling scared or intimidated. Cathy put it this way:

> "I remember when I taught junior high and we were doing fraction strips and I didn't get it and I was so scared to go to the department head to ask for help...I was worried they would think I was stupid or I was a failure."

The view of a positional leader as one who would cast judgment or perhaps undermine a teacher's efficacy by casting doubt on a colleague's ability is troubling. Does fear come from a lack of confidence in advocating for support or a lack of confidence in department heads that are there to help you? Without assistance and encouragement from administration, positional leaders, or colleagues, professional self-improvement will remain an up-hill battle.

Key learnings

Like the research participants, I have grown to enjoy teaching math. My growth has been because of professors, peers, my masters cohort, and close colleagues that have helped me move toward a more positive identity about myself as a learner and teacher of mathematics. One of my personal research goals was to ascertain if math anxiety was an issue with teachers and students at a local level. This project has provided data that has informed my learning about math anxiety, mindset, and teacher and student efficacy.

Yes, math anxiety can be a barrier to learning for students and teachers alike in the mathematics classroom. It is not a constant however. It can be managed, just like other types of anxiety. The participants were intentional about eliminating classroom practices that increased anxiety in themselves and their students, they embraced mistake making as an important part of the learning process, and used direct instruction to teach the language around what a growth mindset looks and feels like.

Research within my own educational context has been encouraging. There seems to be a trend towards a more constructive approach to teaching mathematics at a local level. I was able to hear from teachers that have a genuine desire to improve their practice. The participants were able to draw from early student experiences and use them to slowly change their identities towards math. They have learned to live with the tension between a passive and active learning approach, and found a way to forge a path that builds efficacy for themselves and their students.

The participants demonstrated growth over time as they discussed their math stories, and relayed "the importance of actively engaging students in the math classroom (Finlayson, 2014, p. 114)." This is an important distinction because changing teacher practice is hard work. It is easier to sit students at desks, give them booklets or worksheets, and teach them steps to do all sorts of algorithms. However, my research indicates that this is not the best way forward, and circumvents a deeper understanding of mathematics. A lack of understanding is the root cause of math anxiety.

At times during each interview, there were moments where the participants felt they were working within an educational system resistant to change. Comments in the interviews underlined the tension within their milieus. When Cathy taught junior high, she spent the first week playing math games and focusing on basic facts. She "…took a lot of heat for that from colleagues because it was wasting time." She felt pressured to start on curriculum immediately without ensuring everyone could keep up. Beth talked about her decision to not teach algorithms in early grades without making sure students had a strong number sense. "Teachers think that I'm wrong but…" I sensed that these teachers felt alone in their teaching decisions at times. What needs to change so we can give space for innovative practices that build teacher efficacy? As I write this, we are in the midst of a world-wide pandemic. COVID-19 has forced governments to enact policy changes never seen before. School closures mean online learning. Students will have more voice in what they learn. Students and teachers have an opportunity to be innovative while working within a system that historically changes very little. Perhaps the genie has been let out of the bottle?

What's Next?

Math should not be used as an instrument that separates genders or ability levels. It is a subject that all students can do well in with the right mindset and support in place. The beliefs and messaging around mathematics in my context are changing.

All participants expressed interest in working with their colleagues to build collective efficacy in managing anxiety in themselves and their students. Collaborative work is a key driver in shifting mindsets (Fullan & Quinn, 2016). The time needed to do this effectively is an important consideration. The participants have spent years working on themselves with varied support from colleagues. It is important to positively communicate with one another. Dialogue helps teachers "think together" (Riveros, 2012) as new ideas are created not previously considered. Further, unpacking deeply held beliefs in mathematics will create tension and conflict, and is part of the growth process.

Although my research was at the micro-level, it instilled in me the importance of collaborative cultures in mathematics. Mathematics is for everyone, not just the privileged few. We need to create space for teachers to learn about their anxiety and management strategies without fear of judgment from their peers. The causes and impacts of anxiety on math-anxious teachers may be different for each educator and require different strategies. Despite these challenges; there needs to be a concerted effort to look at ways to support educators with math anxiety. Otherwise, we will not realize the potential of our math teachers and our students.

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