Stopping the Cycle of Math Anxiety: Recommendations for Teachers and Schools

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Abstract

Studied since the 1970s, math anxiety is a perpetual problem faced by schools. The cyclical nature of math anxiety poses a great challenge for educators. A negative experience with learning math is the primary cause of math anxiety, usually first occurring in elementary school. This anxiety often comes from adults who themselves have anxiety about math. Teacher and parent attitude, language and actions have an immense impact on math anxiety. Poor teaching practice, anxiety toward the subject, and negative attitudes can be passed from teachers to students, and also from parents to their children. This article examines best practices for teachers and parents to prevent and stop the cycle of math anxiety. Possible systemic solutions related to elementary math specialists are discussed through the lens of promoting growth-minded perseverance in math students. It is crucial that all adults involved in educating students be mindful of the impact of their attitudes, words, actions and decisions on students' relationship to math.

Introduction

Having taught mathematics in middle school for eight years, I have inevitably encountered students with anxiety, hatred, and fear toward math. "I can't do math," "I'm not a math person" and the popular

"MATH is an acronym: Mental Abuse To Humans" have littered my encounters with students. Math is a scary word for these students because they do not like it, or they feel they are not good at it (Beilock and Willingham 2014). Math anxiety is present in students who underperform, feel hopeless or avoid math class altogether (Anderson 2007; Ashcraft and Kirk 2001). While research on math anxiety spans over forty years, math anxiety continues to be an issue for schools today. This article discusses implications of math anxiety for teachers and investigates possible solutions by providing recommendations for teachers and educational leaders. It examines suggestions for teacher attitude, classroom environment, instructional techniques, assessment practices and parent engagement. Leadership implications include providing support for teachers and exploring potential changes to current school structure to stop the cycle of math anxiety.

Background

Math anxiety is "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems" (Richardson and Suinn 1972, 551). It occurs first in primary grades and increases through the grades, peaking in late middle school or early high school (Jackson and Leffingwell 1999; Al Mutawah 2015; Hembree 1990). Particular topics in math increase anxiety (long division, fractions and algebra), possibly due to exclusivity of math symbols, notation, language or lack of basic skills (Jackson 2008; Buxton 1981; Wu 2009; Schwartz 2002). Math anxiety is not general anxiety, low intelligence or poor math ability (Ashcraft and Kirk 2001; Morris 1981). Students may be successful in other courses but lose self-confidence and become convinced they cannot do math (Morris 1981; Tobias 1993; Dodd 1999). Math-anxious individuals do not gain competence or mastery of mathematical operations (Hembree 1990); fear or nervousness paralyzes thinking, inhibits performance (Morris 1981; Perry 2004) and prevents students from using the knowledge they do possess (Ashcraft and Kirk 2001). Math anxiety interferes with conceptual thinking and memory processes (Newstead 1998; Wilensky 1997), specifically working memory, leading to reduced accuracy of computations and decreased speed of performance (Ashcraft and Kirk 2001; Perina 2002). Students who develop math anxiety fall into a self-defeating, self-perpetuating cycle moving from negative feelings to avoidance to poor mathematical preparations to poor performance and back to negative feelings—a fatalistic attitude reinforcing convictions that they cannot do math, causing the math anxious to become math avoiders (Baroody and Costlick 1998; Preis and Biggs 2001; Morris 1981). This cycle becomes difficult to break when math-anxious individuals conclude for themselves that they cannot sustain success in any math-related situation (Preis and Biggs 2001).

Math itself does not cause anxiety; rather, it is how math has been presented or experienced (Jackson 2008; Stuart 2000). Negative experiences of failure or inadequacy often happen at school and can be influenced by teachers (Finlayson 2014; Jackson 2008; Perry 2004; Raymond 1997). Math anxiety can be passed down to students through attitudes of parents and teachers (Maloney et al 2015; Furner and Duffy 2002; Fiore 1999). Math-anxious parents may communicate their own math anxiety to children through everyday conversation, statements about math difficulty or frustrating family homework experiences (Casad, Hale and Wachs 2015; Jeynes 2007; Finlayson 2014; Maloney et al 2015). This also occurs in school: math-anxious teachers can result in math-anxious students when teachers inadvertently pass on avoidance and fear of math (Martinez 1987; Geist 2010; Wood 1998).

A Teacher's Impact

Teaching has a direct impact on math anxiety—it can take only a single teacher to create lasting math anxiety (Furner and Duffy 2002; Perry 2004). Traditional teaching methods and assessments, focus on results over understanding, and teachers who assume a direct, authoritative role may create math anxiety (Finlayson 2014; Perry 2004; Jackson and Leffingwell 1999; Harper and Daane 1998). Anxiety in struggling students is heightened when teachers give the impression that math is easy; students are told they cannot do math, and subsequently are afraid to ask questions (Finlayson 2014; Perina 2002; Perry 2004).

What teachers do in math lessons may subconsciously reflect their own thoughts and beliefs about the subject (Fernandes 1995). Students tend to internalize their teacher's attitude and anxiety (Jackson and Leffingwell 1999; Martinez 1987; Geist 2010; Wood 1998). Math-anxious elementary teachers can negatively influence instruction and "may promote the early onset of mathematics anxiety" (Hackworth 1985, 8). These teachers may create anxiety through a tendency to use more traditional and teacher-centred approaches (Hembree 1990; Gresham 2008). Elementary teachers who have math anxiety may feel uncomfortable teaching math because they do not like math or feel they are

not good at it (Jackson and Leffingwell 1999; Burns 1998; Stuart 2000; Geist 2010).

Preservice elementary teachers in particular have been found to be a group with anxiety and fear of teaching math (Gresham 2008; Jackson 2008; Raymond 1997). Contributing factors to their anxiety are prior experiences as math students, influence of their teachers at schools, lack of subject knowledge and inadequate teacher preparation programs (Raymond 1997; Goulding, Rowland and Barber 2002). Fear of teaching math among some preservice and elementary teachers may reflect real or perceived knowledge deficits, in part due to university programs that may have little focus on math instruction (Levine 1993; Wingert 2014; Fennell 2006).

This research underscores the importance of great teaching and reminds us of the incredible impact that teachers have on their students. While poor or unintended practices may negatively affect or create math-anxious students, teachers have a great opportunity to make an even greater positive impact on their math students.

What Teachers Can Do

Teachers should take a holistic approach to engaging students in mathematics, considering cognitive and affective aspects of learning (Turner et al 2002; MacLeod 1992). Literature on math anxiety provides a number of key recommendations for teachers.

Create a Safe Learning Environment

"Overcoming math anxiety means that we need to examine the classroom environment and how we teach mathematics" (Finlayson 2014, 102).

Math classrooms should be communities where learners' ideas are valued, students share solution methods, mistakes are valued as sites of learning and the authority for correctness is not solely the teacher but the subject itself (Kilpatrick, Swafford and Findell 2001). Learning math is an emotionally charged practice, because students are taking risks (Schuster and Canavan Anderson 2005). Students are more willing to take risks and ask questions when they feel safe in a classroom with a supportive teacher (Finlayson 2014; Newstead 1998; Wilensky 1997; Wright 1996). Teachers are crucial, because interactions that take place in the classroom are what really matter for math learning (Kilpatrick, Swafford and Findell 2001).

A crucial pillar to creating a safe learning environment is how teachers treat mistakes in mathematics classrooms. While mistakes are important opportunities for learning and growth, students often regard mistakes as indicators of low ability (Boaler 2013). Every time students move out of their comfort zone to learn something difficult and new, neurons form new, stronger connections, and when students think about *why* something is wrong, new synaptic connections are sparked that cause the brain to grow (Boaler 2013; Dweck 2014). Teachers need to encourage risk-taking by repositioning mistakes—not as learning failures, but as valued opportunities for brain development and learning by showing them to all students to consider and recognizing their importance as sites for learning (Boaler 2013).

Success in math will come only when students learn to approach math with confidence and are confident they will not be allowed to fail (Small 2015; Shore 2005; Mighton 2003). Supportive teachers address anxiety and self-esteem to improve confidence in students (Finlayson 2014; Small 2015).

Overcome "I'm Not a Math Person" by Fostering a Growth Mindset

Dweck's (2006) research on mindsets suggests that students display either a "fixed mindset," in which they believe that one is either smart or not, or they develop a "growth mindset" and believe that intelligence and "smartness" can be learned and the brain can grow from exercise. Math, unfortunately, is typically the subject area that communicates the strongest fixed-ability messages and thinking (Boaler 2010).

Math anxiety develops out of the belief that a natural mathematical mind is needed; this myth encourages students to give up when they encounter difficulty (Furner and Duffy 2002; Mighton 2003). When faced with a mistake, math-anxious students believe they are not smart and give up. Their fixed mindset causes them to frequently avoid challenge or anything they perceive as being difficult (Dweck 2006). Math-anxious students believe that success depends on natural talent, but success actually relies on an individual's mindset. Students with a growth mindset both work and learn more effectively, display a desire for challenge, and demonstrate resilience when faced with failure (Dweck 2006).

Teachers can work to dispel the myth of "math people" by telling all students they are capable of doing math and helping them develop a growth mindset (Mighton 2003; Dweck 2006). When teachers emphasize incremental intelligence, working hard and making mistakes to learn, students are more

successful (Dweck 2006). Teachers can help their students develop a growth mindset in a number of ways.

1. *Teach about the brain.* Researchers have found that when students received an intervention workshop based on developing a growth mindset, math performance improved (Dweck, Walton and Cohen 2014). Students need to be educated on the science of the brain. Brains can form new, stronger connections between neurons when faced with difficult, challenging tasks and mistakes are opportunities for learning and growth (Boaler 2013; Dweck 2014).
2. *Encourage students intentionally.* Math-anxious students need teachers to believe in them because they are unaware of their existing strengths in math (Finlayson 2014; Wright 1996). This involves teachers taking a proactive role in encouraging students to see themselves as successful, confident problem-solvers (Finlayson 2014; Furner and Berman 2003). Students need to be praised for their effort and hard work rather than for their intelligence (Dweck 1999). Praising students for their efforts or the strategies they used teaches growth mindset and fosters resilience (Dweck, Walton and Cohen 2014).
3. *Watch your language.* Be intentional about using growth mindset language and avoiding fixed mindset language. When students who face setbacks speak with worry or negative thoughts, feelings or behaviour, it is crucial to respond with constructive thoughts that promote growth mindset related to strategy, excitement of challenge, persistence and growth (Dweck, Walton and Cohen 2014) Students are on a learning journey that can be filled with hills and valleys. Using the words *yet* or *not yet* can give students greater confidence and greater persistence in future learning. The word *yet* can diffuse feelings of failure and encourage children to try again (Dweck 2014). Teachers can promote growth mindset by sending the message that students belong and have great potential (Dweck, Walton and Cohen 2014).
4. *Model a growth mindset.* Teachers must model what they expect from their students. Do not describe yourself as a *math person* or use fixed language. Treat your own mistakes as opportunities for learning, and tell your students about learning from your mistakes. When students believe that everyone's ability can grow, their achievement improves. Similarly, when teachers believe that everyone's ability can grow, student achievement improves (Boaler 2013).

Give Feedback: Recommended Assessment Practices

Math-anxious students do not accurately demonstrate their learning on assessments (Posmentier, Germain-Williams and Jaye 2013). Assessment can create anxiety due to focus on results, right answers, and specific methods instead of understanding (Perry 2004; Jackson and Leffingwell 1999; Harper and Daane 1998; Finlayson 2014). Historically, assessment focused on these products, but the *process* is equally if not more important (Finlayson 2014). Assessment should be focused not on results, but on the development and achievement of mathematical proficiency (Kilpatrick, Swafford and Findell 2001).

The assessments that teachers choose provide opportunity for messages to be communicated to students. If students work on short, closed questions with right or wrong answers, getting frequent wrong answers makes it difficult to maintain a view that achievement is possible with effort (Dweck, Walton and Cohen 2014). Similarly, engaging students in constant repetition of short, closed questions without making mistakes does not provide the same opportunities for growth and development that making mistakes in challenging work provides (Boaler 2013). By contrast, open-ended tasks provide opportunities for learning and allow students to see the possibility of higher achievement, giving them a chance to improve, in line with Black and Wiliam's (1998) research on formative assessment.

Formative assessment supports the building of confidence by encouraging and directing students to find the right answer by systematically analyzing their mistakes (Posmentier, Germain-Williams and Jaye 2013). This feedback teaches students how to convert failures into successes by providing an opportunity to correct mistakes and improve their understanding of mathematical concepts. Mistakes should not be marked with a cross but rather with a happy face and comments about the opportunity the mistake provides for learning (Boaler 2013). Assessment communicates what teachers value (Wilson and Kenney 2003), and providing second opportunities spreads the belief that students can master the concept and will be not be allowed to fail. Using a variety of assessment techniques is key. Open-ended assessments provide detail on student strategies and understanding, and long-term projects allow depth of exploration (Wilson and Kenney 2003). Use of observations and rubrics has been shown to reduce anxiety, and portfolios provide opportunity for students reflect on their work to build confidence (Wilson and Kenney 2003; Finlayson 2014). Journal writing has been shown to

reduce math anxiety and increase student learning (Connor-Greene 2000; Furner and Duffy 2002; Furner and Berman 2003; Salinas 2004). Self-assessment allows students to have input into their own evaluations, which further reduces anxiety (Furner and Duffy 2002).

Assessment in any form is feedback given to students that can serve either to motivate or to discourage (Schimmer 2016). Every piece of feedback sends messages, however subtle, that shape student motivation, making students more or less tenacious learners and, consequently, more or less anxious (Dweck, Walton and Cohen 2014). As such, assessment should be designed with care.

Teach for Understanding: Instructional Strategies

Math-anxious students attribute their discouragement to a lack of interactive, creative and relevant learning experiences (Jackson 2008). Students need more than demonstration of procedures, but also experience in investigating mathematical properties, justifying solutions and analyzing problems (Kilpatrick, Swafford and Findell 2001). When teachers employ best practices for teaching math, students understand and learn math, and anxiety is reduced (Furner and Duffy 2002; Alkan 2013). Math anxiety is further reduced when math is connected to real-life situations with a series of problem-based activities (Finlayson 2014; Ernest 1989; Van De Walle 2004) and a more student-directed class with teacher facilitation (Finlayson 2014; Mutodi and Ngirande 2014; Newstead 1998; Wilensky 1997). Constructivist, collaborative, open-ended instructional design encourages a positive response from students (Finlayson 2014).

Interactions that take place within the classroom are crucial. Teachers play a key role as orchestrator of mathematical conversations and should provide opportunities for students to offer solutions, make claims, and provide explanations to their peers (Kilpatrick, Swafford and Findell 2001). Exploring multiple ways to solve problems and allowing students to choose their method empowers students to construct personal approaches and unravel misconceptions, thus building self-confidence (Finlayson 2014; Schuster and Canavan Anderson 2005). Teachers must permit students to discover why their approach does or does not work and allow them to surrender ineffective strategies to avoid creation of math anxiety and self-doubt regarding reasoning skills (Clement, Narode and Rosnick 1981). Students must learn to trust their own methods of understanding the material if teachers are to achieve the critical goals of creating understanding and confidence in their students (Clute 1984; Finlayson 2014; Small 2015).

Engage Parents

Positive parent involvement is crucial to reducing math anxiety (Alkan 2013; Furner and Berman 2003). Due to their shared position as role model, parents must be educated on the impact of their beliefs, words and actions regarding math (Casad, Hale and Wachs 2015). Parents should not talk to their children of their own dislike of math or of their own math weaknesses, because this gives the child permission to be the same way (Small 2015; Maloney et al 2015). Educating parents on the science and language of growth mindset can empower them to help develop that mindset in their children.

Home support helps to reduce math anxiety in students, and schools need to develop better tools for parents to get involved (Vukovic, Roberts and Wright 2013; Maloney et al 2015). Parents are usually willing to help with reading at home, but often assume that the school will take care of math instruction (Berkowitz et al 2015). A strategy for elementary schools may be to develop a home math program, such as encouraging parents to read math stories to help children develop better, more situated math understanding (Berkowitz et al 2015). Beyond that, schools should make efforts to educate parents as to why they should and how they can help their children develop a sense of number and shape in childhood. (Kilpatrick, Swafford and Findell 2001).

Specific parent involvement strategies remove ineffective homework help that contributes to math anxiety if parents do not understand the homework and express their lack of understanding (Maloney et al 2015). Parent strategies should include asking their child questions, teaching children to ask good questions, encouraging children to teach their parents, believing in their children and being conscious of their own behaviours related to math (Small 2015).

What Schools Can Do

Prepare and Support Teachers to Overcome Math Anxiety

Great teachers are "the key to many students' ability to learn mathematics" and possess "pedagogical content knowledge, built upon a deep understanding of how students think and develop mathematically" (Small 2012, 2). Attitude, however, is a stronger influence than skill and, consequently, addressing

teachers' attitudes toward math may be more important than addressing their knowledge of math (Jackson 2008). Elective professional learning is not enough, because teachers with a reform-oriented view of math choose to engage, while others believe that increased prep time is more beneficial than subject knowledge and avoid these opportunities (Larsen 2012; Chavez, Widmer and Carroll 1982; Allen 2010). While nervousness about teaching math should lead to learning about content and asking for help, a teacher who may unconsciously hold the belief that it is acceptable to be "not good at math" may find that his or her attitude inhibits the effectiveness of addressing the lack of pedagogical content knowledge (Small 2015).

Math anxiety, therefore, must be addressed by school-level professional learning. Teachers with a lack of subject knowledge do not plan as effectively, and some elementary teachers struggle with alternative strategies, estimation and other areas due to their own misconceptions (Goulding, Rowland and Barber 2002; Good 2009). Knowing which mathematical concepts teachers struggle with can help to set priorities for future professional learning, which should include "mathematically rich activities that cause participants to acknowledge their current knowledge, recognize if this knowledge is comprised of any mathematical misconceptions, and transform their current knowledge into mathematically correct knowledge" (Good 2009, 165). The biggest challenge facing leaders of professional learning is teachers who are recovering from their own math anxiety. Therefore, it is essential that leaders treat participants of professional learning as they would a class of students. Leaders must create a climate in which teachers feel safe to express their negative feelings toward math (Chavez, Widmer and Carroll 1982). Teachers will not be successful at math until leaders build their confidence by listening to their concerns and ideas and gently moving them in the right direction (Small 2015).

Organizing Schools to Reduce Math Anxiety

A student's view of what it means to know and do math is shaped in elementary school, by generalist teachers (Fennell 2006). Few teachers, particularly in elementary schools, currently have the specialized knowledge required to effectively teach mathematics as the curriculum was envisioned; this is not a teacher's fault, because it is a significant task to obtain this knowledge—beyond what can be expected to occur in a teacher's spare time (Kilpatrick, Swafford and Findell 2001).

As generalists, elementary teachers may find it difficult to develop in-depth math knowledge and expertise in teaching mathematics (National Council of Teachers of Mathematics [NCTM] 2010). Many elementary and even middle school teachers don't view themselves as experts, yet they are tasked with teaching math with a limited understanding of the subject and a hesitance to teach for conceptual understanding they may not themselves possess, and as a result lean on traditional teaching approaches (Wingert, 2014; Lott, 2003). Their preservice background and general teaching responsibilities are not typically conducive to the continuous development of specialized knowledge for teaching math, but elementary specialists provide a solution (Wingert 2014; Fennell 2006).

Specialized Teacher Model: Elementary Content Specialists

It is unrealistic to expect elementary generalist teachers to possess deep math content knowledge when considering the advanced knowledge they must gain of how to teach reading (Wu 2009). The problem of raising the mathematical proficiency of all elementary teachers is immense, requiring considerable changes to preservice training, and could be best solved by changing the traditional model of elementary generalist teachers (Wu 2009). Math anxiety starts early, yet content specialist teachers are present only in the latter years of students' academic careers. A specialized teacher model gives one teacher, with deep content knowledge, the primary responsibility for teaching math (Fennell 2006). These teachers bring greater confidence to the classroom and use their specialized knowledge to produce a higher quality of work (Hennessy 2000; Wilson et al 2008). Arts and physical education employ subject specialist teachers at the elementary level because nonspecialists are less effective in developing skills, reverting to traditional activities they experienced as students—yet there are not specialists in elementary math, a core subject (Lott 2003). Specialists possess understanding of key mathematical concepts, and in order to teach math the right way, it is crucial to create a corps of teachers with this knowledge (Wu 2009). This allows school districts to focus professional development on a targeted group of teachers and has "economic benefits because it does not require additional teachers, just a redistribution of teaching responsibilities" (Fennell 2006). High-performing

Asian countries use elementary specialists starting in Grade 3 (Wingert 2014).

The model is not without its drawbacks, however, as studies have shown that specialist math teachers in Grades 5 and 6 have not proven to make a significant impact (McGatha 2009). Perhaps Grade 5 is too late to begin to use specialists, due to early onset of math anxiety. Conversely, it is important to consider the message the specialist model may send—that only math specialists can teach math—potentially interpreted by students as that only some adults are good at math, and it is therefore acceptable to not be good at math. While this could contribute to the cycle of math anxiety, something needs to be done to try to prevent development of math anxiety in students.

Lead Teacher Model: In-School Math Teaching Experts

A less radical change to the current structure of elementary schools is to use math specialist teachers, similar to the literacy specialist teachers already common. These on-site specialists provide continuing, comprehensive support to teachers and students in one specific school, focusing primarily on teacher development, planning lessons with teachers in the classroom and providing authentic professional development in real time (Wingert 2014). Teachers need to model the mindset they expect of their students, and this model restructures schools as places to learn, where teachers are given opportunity to learn and support to advance their craft (Stigler and Hiebert 1999).

Mathematical knowledge is a critical resource for teaching; therefore, every school needs access to math teaching expertise and should provide teachers with opportunities to develop their own knowledge about math and math education (Kilpatrick, Swafford and Findell 2001). This model gives teachers more time to effectively plan lessons, leading to improved student achievement and possibly less anxiety (McGatha 2009; Wingert 2014). Math specialists have been found to help teachers overcome insecurity, feel more confident and positive, and learn multiple ways to teach math (Blount and Singleton 2007; Wingert 2014). Short or one-off professional learning has proven to be ineffective, so by having an in-school specialist, teachers can work together to continue to learn and develop their practice (Kilpatrick, Swafford and Findell 2001). Furthermore, this ongoing, embedded professional learning can extend beyond teachers to educational assistants.

The model of supportive math specialists may be the only practical way to make change (Wingert 2014). While it may not be as time or cost efficient as the subject specialist model, it sends the message that math can be learned by all, fostering a growth mindset in teachers and students alike. When teachers believe that everybody's ability can grow (including their own), students tend to achieve at higher levels (Boaler 2013).

Conclusion

The self-defeating cycle of math anxiety is a significant problem shaped by students' experiences while learning math. Educators have a responsibility to ensure that students have positive experiences of learning math in a safe, growth-minded environment supported by sound assessment practices and instructional strategies that emphasize understanding over results. Teachers have the opportunity to model a growth mindset and positive attitudes toward math while encouraging parents to do the same by giving them specific support strategies. Educators need to research and implement programs to educate parents about math anxiety and involve parents in their child's math education. Schools need to prepare and support teachers to address math anxiety in both themselves and their students through ongoing school-based professional learning. Two possible solutions worth exploring at the school level are elementary math content specialists and lead teacher math specialists.

Leaders need to be aware of the implicit messages that they send to students regarding math anxiety, and explicitly address these in their own decision making with staff members and with parents. The best way to break the cycle of math anxiety is to prevent it from starting to begin with. All stakeholders in a student's life need to be involved and, more importantly, aware of the role they can play in reducing math anxiety by communicating a positive attitude and a growth mindset toward learning math.

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