Math Anxiety and Attitudes Toward Mathematics
Implications for Students with Mathematics Learning Disabilities

by Allyson J. Kiss and Rose Vukovic

"I am not good at math." "I hate math." "I am not a math person." Such sentiments are common among many children and adults, including those with difficulties or disabilities in mathematics (Beilock & Willingham, 2014). Up to 93% of students report at least some negative experience with mathematics from kindergarten through college (Jackson & Leffingwell, 1999). Students with strong negative beliefs and feelings about mathematics are more likely to experience lower performance in mathematics (Ashcraft, Krause, & Hopko, 2007; Ma & Kishor, 1997). Thus, it is important to consider both attitudes and anxiety when working with students who struggle with mathematics or who have mathematics learning disabilities (MLD). Math anxiety and attitudes toward mathematics do not necessarily cause MLD, but both may interfere with the successful learning of mathematics. The purpose of this article is to describe both math anxiety and attitudes toward mathematics as they relate to struggling math learners, including how they develop, how they relate to learning, and some practical strategies to help reduce math anxiety and foster positive attitudes toward mathematics. It is worth noting that the current state of knowledge on attitudes toward mathematics and math anxiety has not delineated a distinct trajectory for students with and without MLD, so we focus on students in general and highlight findings specific to MLD where appropriate.

Math Anxiety

Anywhere between 6 to 60% of school-age students experience math anxiety (Dowker, Sarkar, & Looi, 2016), which involves feelings of worry or fear that interfere with the ability to work with numbers and solve mathematics problems both in real-world situations (e.g., making change at a store) and in the classroom (e.g., being called on by teachers). Similar to other performance-based anxieties, math anxiety involves physiological arousal (e.g., sweaty palms), intrusive thoughts (e.g., "I'm going to fail the test"), and escape and/or avoidance behaviors. When mathematics cannot be escaped, performance deficits have been observed across the lifespan from childhood to adulthood (Dowker et al., 2016; Hembree, 1990).

Math anxiety impedes mathematical learning in two ways. First, math anxiety leads to avoidance behaviors, meaning that math-anxious students participate less in mathematics class (Ashcraft et al., 2007), take fewer mathematical credits, and, importantly, avoid taking advanced mathematics courses that are essential in attaining full economic opportunity (Moses & Cobb, 2001). Second, for students with high levels of math anxiety, intrusive thoughts may co-opt the working memory resources necessary to complete mathematical tasks. These students may have to put forth more effort during learning as they have the dual cognitive challenge of managing both their math-anxious thoughts and solving the mathematics problem at hand, which often leads to slower and less-accurate performance (Ashcraft et al., 2007). Although working memory limitations in students with MLD are well documented, emerging research suggests that math anxiety may also be a defining characteristic of this population (Passolunghi, 2011). Thus, math anxiety may be an additional barrier to learning for students with MLD.

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Development of Math Anxiety

Although math anxiety has long been linked to lower achievement in mathematics, emerging research is only beginning to elucidate the developmental course of math anxiety. Early hypotheses posited that math anxiety emerged in middle school as a result of consistent exposure to negative feedback and failure in conjunction with increasing curriculum demands (e.g., Ashcraft et al., 2007). However, developing research demonstrates that math anxiety can occur as early as first grade (Harari, Vukovic, & Bailey, 2013), indicating that some children may not need years of negative experiences to report feeling math anxious. Even still, levels of math anxiety increase as students move throughout elementary school, reaching a peak in middle school and stabilizing in adulthood (Hembree, 1990), indicating that school experiences do contribute to the development and maintenance of math anxiety.

Students with MLD may be more susceptible to developing math anxiety, given their higher vulnerability to stress (McQuarrie, Siegel, Perry, & Weinberg, 2014), a propensity for lower working memory capacity (Geary, 2004), and a history of negative experiences with mathematics. In fact, students with MLD tend to report higher levels of math anxiety compared to their typically and low-achieving peers (Lai, Zhu, Chen, & Li, 2015; Wu, Willcutt, Escovar, & Menon, 2014), yet, the reasons

Continued on page 36

Abbreviation

MLD: Mathematics learning disabilities

why math anxiety develops differently for these students is still under investigation.

Researchers are beginning to understand how math anxiety might develop differently for girls and boys. Although girls in middle and high school consistently report higher levels of math anxiety (Dowker et al., 2016), *how* math anxiety affects students suggests a more nuanced story. Specifically, math anxiety appears to negatively influence arithmetic calculation skills in males and problem solving in females, despite both genders reporting similar levels of math anxiety (Devine, Fawcett, Szűcs, & Dowker, 2012; Miller & Bichsel, 2004). In our research with young children, math anxiety in first grade negatively predicted mathematical performance in fourth grade in girls only; in boys there was no relation. This suggests that young girls pay a higher price for being math anxious than do boys (Casanova, Vukovic, & Kieffer, 2016). In older students, math anxiety may be driven by poor performance for boys, while levels of math anxiety tend to be stable in girls regardless of their mathematics achievement (Ma & Xu, 2004). Together, these findings suggest that for girls—including those with MLD—it may be even more important to prevent or reduce math anxiety at an early age.

Attitudes toward mathematics inform practitioners and parents about students' approach to learning mathematics and may serve as an early indicator of math anxiety.

Findings from research with parents and teachers provide clues about the social mechanisms that impact the expression of math anxiety in students. Math anxiety in parents can reduce parental involvement behaviors (Lozano & Vukovic, 2016), and teachers with math anxiety have students who learn less mathematics (Beilock & Willingham, 2014). This is not to say that parents and teachers intentionally impede student learning, only that math anxiety in adulthood is neither simple nor straightforward. For instance, math anxiety can lead parents to feel as though they lack the skill or resources necessary to help their children academically and consequently they may avoid involvement (Gunderson, Ramirez, Levine, & Beilock, 2012; Vukovic, Roberts, & Green Wright, 2013; Waanders, Mendez, & Downer, 2007). Similarly, teachers with math anxiety can lack confidence in teaching mathematics (Gresham, 2008), resulting in less time teaching mathematics and using less inclusive practices in their classrooms (Mizala, Martínez, & Martínez, 2015). Although math anxiety in adults may have unintentional effects, providing support for learning and having high educational expectations may lessen the negative effects on students (Lozano & Vukovic, 2016; Vukovic et al., 2013). Given that teachers often hold lower academic expectations for students with learning disabilities (Clark, 1997), it is plausible that students with MLD may be especially impacted when working with teachers with math anxiety. This is an important consideration for teacher training and professional development.

Attitudes Toward Mathematics

Most educators want students to enjoy learning mathematics; however, many students express negative attitudes toward mathematics. At the simplest level, attitudes toward mathematics refers to the liking or disliking of mathematics (Ma & Kishor, 1997), but also includes self-confidence in mathematics and perceived usefulness of mathematics. Unlike math anxiety, which disrupts learning in real-time, attitudes toward mathematics influence how students *approach* learning. That is, when students have confidence in their mathematics skills and enjoy and see the value of mathematics, they tend to have higher levels of engagement and put forth more effort, which in turn makes them more resilient learners (Wigfield & Eccles, 2000). Importantly, negative attitudes toward mathematics may developmentally precede math anxiety (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Casanova et al., 2016; Ma & Xu, 2004) whereas positive attitudes may help manage or reduce the negative effects of math anxiety (Galla & Wood, 2012). Thus, attitudes toward mathematics inform practitioners and parents about students' approach to learning mathematics and may serve as an early indicator of math anxiety. This is an important consideration for students with MLD, who tend to report more negative attitudes toward mathematics compared to their typically achieving peers (Hanich & Jordan, 2004; Zeleke, 2004).

Development of Attitudes

Attitudes toward mathematics are influenced by a combination of previous experiences and social mechanisms. Younger students tend to hold more positive attitudes toward mathematics compared to students in later grades (Ganley & Lubienski, 2016), suggesting that school-based experiences play a role in how negative attitudes toward mathematics develop. In fact—similar to math anxiety—more difficult mathematics curriculum over time yields repeated opportunities for students to experience persistent learning challenges. When such challenges are not accompanied by sufficient resolution or mastery, students may shift how they perceive mathematics from positive to negative (e.g., Wigfield & Eccles, 2000), thus shaping how they approach future mathematics in the classroom and in real-world settings. Previous (negative) experiences with mathematics may be especially formative for students with MLD considering that these students tend to perceive the same mathematical content as more difficult than their typically achieving peers (Montague, 1997). Thus, students with MLD, who by definition have a history of repeated difficulties with mathematics, may need more support to persist with challenging material until they experience some success in learning.

Although many students enter school with positive attitudes toward mathematics, some students as young as prekindergarten have been observed to be disinterested in mathematics (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012). This suggests that factors outside of school experiences have an impact on how attitudes toward mathematics develop; we consider gender socialization and adult-student interactions specifically. Although there is limited evidence of a gender gap in mathematics achievement across the school-age years, boys report higher levels of self-confidence in mathematics as early as third grade (Lubienski, Robinson, Crane, & Ganley, 2013), and this gender gap in attitudes remains throughout the school-aged years (Else-Quest, Hyde, & Linn, 2010). This suggests that girls may be more likely to be socialized to hold negative attitudes toward math even though their achievement may be the same as their male peers (or better, to the extent that lower self-confidence limits how girls are able to demonstrate their mathematical knowledge). Gender socialization ranges from implicit cultural stereotypes that math is for boys to explicit messaging that boys and men have natural talent in mathematics (Gunderson et al., 2012). Girls with MLD in particular may experience less enjoyment from mathematics and more hopelessness and shame about their mathematics performance compared to their peers with and without MLD (Holm, Hannula, Björn, 2016). Together, the literature suggests that gender socialization negatively affects girls' attitudes toward mathematics beyond experiences of low performance, especially for girls with MLD.

Parents and teachers have their own history related to mathematics and how they communicate their attitudes to students has the potential to improve or hinder mathematics learning.

Adult-student interactions also play a role in how attitudes toward mathematics develop. Students who perceive that their parents or teachers believe that math is a fixed ability, is not valuable, or is too hard tend to hold negative attitudes toward mathematics (Eccles & Jacobs, 1986; Rattan, Good, & Dweck, 2012). This is not to say that parents and teachers *cause* students to have negative attitudes toward mathematics. Rather, parents and teachers have their own history related to mathematics and *how* they communicate their attitudes to students has the potential to improve or hinder mathematics learning. For example, when students hear from trusted adults that mathematics is important and that they can succeed with hard work, students are more likely to persist when faced with difficult mathematics tasks and may be more motivated to take more difficult classes (Swanson, Valiente, Lemery-Chalfant, Bradley, & Eggum-Wilkens, 2014). Similarly, students who perceive greater support in mathematics from parents and teachers have more positive attitudes and higher self-confidence in mathematics (Rice, Barth, Guadagno, Smith, & McCallum, 2013), even if students have had negative experiences with mathematics in the past (Eccles & Jacobs, 1986). Importantly, students have higher self-confidence when they perceive that teachers care about students' mathematical learning and support mastery of progressively challenging material (Fast et al., 2010). This has important implications for students with MLD, who may need teachers to be especially caring and supportive as they confront new and challenging mathematics material.

Implications for Practice

High quality instruction and skills-based interventions are important. But given that previous mathematics performance is only one of many influences on math anxiety and attitudes toward mathematics, they may not be enough to help students succeed, especially students with MLD. Teachers and parents might consider the following strategies to reduce math anxiety and foster positive attitudes toward mathematics.

Social Support

An important consideration is *how* adults talk about mathematics. Teachers and parents can encourage students to focus on the process and mastery of learning over test scores or specific assignments (Fast et al., 2010). It is not that wrong answers are bad and correct answers are good, but rather that learning mathematics is a process, and errors are expected. Fixed thinking such as "I'm not good at math" tends to limit student achievement, while a growth mindset approach such as "I can be good at math if I work hard" helps motivate students and foster positive attitudes (Rattan, Good, & Dweck, 2012).

Parent involvement may also help reduce the effects of math anxiety among students. This does not necessarily mean that parents need to provide direct homework support or instruction, but parents can help their children by encouraging the importance of learning mathematics. Parents can also emphasize everyday opportunities for mathematics such as helping with recipes, making purchases at stores, discussing sports scores and statistics, and playing board games (Beilock & Willingham, 2014; Vukovic & Harari, 2013). Teachers can also use these strategies in the classroom to relate mathematics to real-world experiences.

Assessment Strategies

Providing math-anxious students more time to better work through solving complex problems helps reduce worries about completing tests and assignments. Teachers can also give opportunities to re-take tests, correct errors, and provide formative feedback (Beilock & Willingham, 2014). Another evidence-based strategy is to give students 5 to 10 minutes immediately before an exam to expressively write about their anxiety concerning the exam (Park, Ramirez, & Beilock, 2014). Expressive writing provides a mechanism for students to manage their negative thoughts and may increase the availability of working memory resources for the exam.

Instructional Strategies

Effective instruction for improving achievement for students with MLD may also help alleviate effects of math anxiety and improve student attitudes toward mathematics, such as explicit

Continued on page 38

instruction, formative feedback, motivators (Supekar, Iuculano, Chen, & Menon, 2015), and cooperative learning (Lavasani & Khandan, 2011). Another related instructional strategy is to provide students with opportunities for success in mathematics. This might involve determining a student's ability level and selecting practice tasks that include easy and challenging material (Boaler, 2013). When students are able to correctly answer items, they are encouraged to spend more time practicing, which can reduce math anxiety and improve confidence (Jansen et al., 2013).

From Anxious to Enjoyable

Identifying math anxiety and discerning attitudes toward mathematics are essential in understanding how students engage with mathematics. Practitioners and parents should be aware that these aversions to mathematics create additional barriers to learning for students with MLD. Fortunately, emerging evidence suggests that positive social experiences and educational practices can help create environments where students with MLD can enjoy learning mathematics.

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