▲ An Examination of Math Anxiety Research

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Math anxiety can be defined as a feeling of nervousness, unease, or tension that "interferes with math performance" (Ashcraft, 2002, p. 181). Taking liberties with this definition, math anxiety can be considered within the category of transmissible or communicable "diseases," which may lie dormant within individuals for many years. From this new perspective, this article will provide a brief look at the characteristics of this illness, will outline some of the most common symptoms exhibited by hosts, and detail some of the recent advances in science that aim to manage or control and alleviate some of these damaging symptoms. Alternatively stated, this article is an "examination" of math anxiety research. Further, we provide a brief outline of possible measures that can be taken to prevent the further spread of this infectious disease.

Classification

Arguably, most everyone in society today is a student of math to some extent. Math is all around us throughout our daily lives, from knowing how far one can travel on the gas remaining in a tank; understanding and using plans for three-dimensional structures; interpreting and questioning charts on the evening news or polls on a Twitter feed; measuring ingredients to create a meal; estimating the volume of luggage versus trunk space; to figuring out a monthly budget or doing annual taxes. The need for at least a basic level of numeracy in modern society is inescapable. However, in the hope that there might be some practical applications, this paper will focus on math anxiety from two distinct perspectives in the educational institution—that of the math student and from the position of the math teacher.

While anxiety runs rampant in Western society today, we focus on a particular strain that is found in educational institutions around the world. Even with general anxiety and anxiety in school not being new subjects, the fields of math anxiety and math teacher anxiety are considered relatively new areas of study. Math teacher anxiety, itself, likely existed as far back as the first time, for example, a mathematician tried to explain the lunar phase counter tally marks on a "Lebombo Bone" to her husband, or for Thales of Miletus the first day as he walked into the Academy of Athens to teach. Much more recently, Dutton (1951) wrote that teacher candidates, who were studying math methods, had a negative attitude toward mathematics and the teaching of the subject. Since that time, there has been increasing interest and broadening study of math anxiety.

The multiple causes of math anxiety can be classified in two interrelated groups: internal and external causes. We are interested, here, primarily in those external factors or causes that can be linked to the classroom and home environment. We will turn our focus to cause and transmission of math anxiety in the next section. It should be noted here, however, that at least some research indicates that student math anxiety is a result of how the student learns math—the style or type of authority used in the classroom (Stodolsky, 1985), the imposition of timed responses and exposure of the student (among other factors) (Ashcraft, 2002), emphasis on the correct answer or fear of mistakes (Tobias, 1978)—can all contribute to the level of anxiety that a student might develop.

Math anxiety is troublesome for both sets of teachers and students, albeit for different reasons. For the student of math, symptoms of math anxiety might include a rise in heart rate, sweating, nausea, stomach discomfort or disorders, headaches, confusion, and even panic. A recent study by Lyons and Beilock (2012) even linked higher anxiousness related to math work with increases in activity in "regions associated with bodily threat detection and the experience of visceral pain itself" (para. 24). The varying symptoms can lead to many negative behaviours,

including lack of confidence, panic, poor performance, and avoidance. Students that suffer these symptoms may tend to avoid studying math, which then potentially limits future education and career paths as well as impairs their ability to survive and excel in modern society. Ashcraft (2002) calls this a "global avoidance tendency" (p. 181), which can limit students in two ways. First, they rush through work in an attempt to limit the amount of time that is spent working on math. Secondly, they try to reduce, via course selection, the amount of time spent studying math. Some work done is this area suggests the impact of anxiety on course selection and math success is not significant (e.g., Meece, Wigfield, & Eccles, 1990). There are also a number of studies (e.g., Beilock, Holt, Kulp, & Carr, 2004; Beilock, Gunderson, Ramirez, & Levine, 2010; Furner & Berman, 2003, 2005; and others) that have examined the link between math anxiety and math performance, finding a significant relationship between the two. The field of work in anxiety research continues to grow today (e.g., Clark, 2013; Rancer, Durbin, & Lin, 2013; Ganley & Vasilyeva, 2014; Jameson, 2013; Harari, Vukovic, & Bailey, 2013; and others). Leaving aside the debate over anxiety and performance results, we can clearly see that there are a number of negative outcomes or limitations (at the least), for anyone suffering from math anxiety. For this reason alone, we contend there is a benefit to trying to alleviate this anxiety, if possible.

For the teacher of math, anxiety can result from similar roots, but play out in a far different fashion than for that of the student. Bush (1989) determined that teachers who were math anxious retreated from current best practice guidelines and instead used more traditional teaching styles involving individual seat work and focusing on skills instead of concepts. The relationship between teacher and student anxiety will be the subject of the next section on transmission.

Transmission

The research indicates that a student is made more or less susceptible to math anxiety by certain conditions in the classroom. "Common practices leading to increased anxiety were emphasis on drill and practice, getting the right answer and using the right method, taking timed tests, memorizing formulas, and applying rules" (Harper & Daane, 1998, p. 30). Said conditions are some of the very same that the math-anxious teacher may retreat to when instructing mathematics. While both boys and girls are impacted in the teacher-to-student transmission of this anxiety, in early elementary education, where the teachers are predominantly female, girls may be more severely impacted than boys. Beilock, Gunderson, Ramirez, and Levine (2010) recently confirmed that "where teachers are almost all female, teachers' math anxiety carries consequences for girls' math achievement" (p. 1861). The transmission by teachers of math avoidance, and general unease with math, appears to be consistently supported in the literature (e.g., Furner & Bermann, 2005; Vinson, 2001; Hembree, 1990; and others). While transmission of math anxiety is possible, so is prevention, which we now address.

Prevention

Math teachers play a critical role both via internally held beliefs as to their own mathematical adequacy, skills, and talents, as well as externally in their daily practice or approach to teaching, through which the mathematics instruction is delivered. As such, this section will provide a brief review of several suggested approaches as to how math anxiety can be reduced or prevented in students. Owing to the related issue of teachers' math anxiety, this section will also touch on approaches to reducing or preventing math anxiety in students.

Most of the suggestions for reducing math anxiety in students align well with current thought in prospective teachers' programs at various universities across Canada. In their review of related research, Furner and Berman (2003) compiled the following list from the National Council of Teachers of Mathematics Standards: teaching how to think for oneself; working in groups at all levels of math; efficiently using technology; teaching estimation; including more statistics and probability in the early grades; incorporating fewer computational processes and drills; using manipulatives; and focusing on more realistic problem-solving experiences. Other best practices gleaned from current writing practices in the math class include: incorporating more writing to explore mathematical thinking and problem solving (Pugalee, 2001; Schoenfeld, 1992); importance of questioning and conjecture (da Ponte, 2001; Ball, 1993); revising assessment to allow for multiple ways to demonstrate understanding (Pirie & Kieren, 1994; Simon, 1995); and alternative forms of assessment including performance tasks, self-assessment (Kulm, 1994; Artzt, Armour-Thomas, Gurl, & Curcio, 2008), portfolios, and writing samples (Midkiff & Thomasson, 1993).

In order to reduce or prevent math anxiety in the student then, the math teacher must engage in careful and reflective practice that ensures a more humanistic approach suited to each learner in the classroom. He or she must engage in helping the student to actively, excitedly, and

independently inquire into problems, rather than memorize procedures, and also allow for multiple ways to solve a problem and demonstrate that understanding.

A critical first step in ensuring the success of the learner in the math classroom is to be sure that the teacher will not be transmitting personal biases or negative practices to students. Harper and Daane (1998) suggest that the first step is for teachers to be aware of their own personal level of math anxiety. With this knowledge, they are then better able to make adjustments in their own practice to prevent passing on negative dispositions to students. Gresham (2007) points to teacher education programs as the critical point to make teachers aware of their bias, and work to change it to a more positive one.

Conclusions

Math anxiety is recognized as a concern for many students today. If it is not identified and addressed, math anxiety could potentially lead to lower performance in math, which can further impact students via limitations in education and career options. Relatedly, math anxiety in the math teacher has similar root causes as it does in students; however, with instructors, math anxiety, unfortunately, can be transmitted to students. Fortunately, math anxiety can be overcome by reflective, diligent, and confident instruction.

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