MATH ANXIETY IN THE SCIENCE CLASSROOM

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"I was never any good at math."
"This is probably a stupid question
"I know that I should know how to do this."
"What's the use. I won't be able to do it anyway."
"Everyone knows what to do but me."
"I don't have a math/science mind."

Do you hear comments such as these from your science and mathematics students? In spite of your excellent teaching and their high motivation, many students do poorly in sciences such as chemistry and physics. One possible reason for this difficulty is mathematics anxiety. How can we identify some of its symptoms, the implications of these symptoms for learning, and suggested interventions for use to assist students who experience debilitating anxiety? The recommendations arise from recent research in mathematics anxiety, from our experiences in mathematics and chemistry classrooms, and in a program designed to help overcome mathematics anxiety.

Mathematics anxiety is defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems." 4 Because chemistry and physics involve using and understanding mathematical relationships and performing mathematical calculations, the interference that mathematics anxiety causes can be devastating to students in these classes. Thus, it is important that science teachers recognize situations in which mathematics anxiety may be contributing to a student's difficulties and that these teachers are knowledgeable about ways to help students overcome this anxiety.

Long before they begin college, many math-anxious students have opted out of the science and mathematics preparation necessary for their preferred careers. Early identification and treatment of math anxiety can lead students to better preparation in mathematics and science and, therefore, a wider field of career opportunities. Assisting math-anxious students in dealing with their anxieties and resultant difficulties may lead to greater success in required science courses. Math anxiety is like a disease. The earlier the diagnosis takes place and treatment begins, the less damage is done to the student. The longer negative beliefs and attitudes about mathematics exist, the more resistant these beliefs are to change and the more mathematics and science the student will have "missed-out" on in school. Thus, the earlier the problem is diagnosed, the easier the problem is to alleviate.

Examples from the Chemistry Classroom

Each of these students was enrolled in a university course in general chemistry. Their experiences are typical of math-anxious students.

Donna is a bright, hard-working, enthusiastic student who wants to become a pharmacist. She took general chemistry four or five times. Each time she either dropped the class, or did not earn a grade higher than a "D."

Jane is a freshman who was at the top of her high school class in everything but math. During exams she gets so ill she often has to leave before finishing. She gets visibly .tense when someone puts an equation on the board in class.

Robert is about 40. He returned to school when his farm went broke. He is hard-working and highly motivated; he has excellent math skills. However, when taking tests or working chemistry problems his blood pressure elevates dangerously -- so much that he can not think clearly. Because of his distress, he does very poorly on exams and quizzes.

Gwen entered the university as a freshman in pre-pharmacy. She had excellent high school grades in all her courses except mathematics and chemistry. We first met her when her teaching assistant brought in a copy of her first lab report. None of the data in her report matched the data collected in lab. The teaching assistant believed that Gwen had been cheating. However, her intent was not malicious. Upon talking with her, we found that the data and equations

in lab upset her so much that she could not even try to make sense of them. So, she employed a strategy that had been previously successful; she had someone else to do the work for her. In this case, however, the teaching assistant who "helped" her with the calculations made up data to use in sample calculations. Gwen did not understand the numbers and calculations (in spite of the accompanying explanations) so she did not know what the numbers meant or where they came from. She was shocked to find out that the numbers were not correct and felt the teaching assistant was negligent in not doing the "correct calculations" for her. After this, Gwen spent many hours throughout the semester working with the faculty teaching assistants, tutors, and other sources of help in chemistry. Her math anxiety was so severe, however, these efforts were of no avail and she failed the chemistry course and switched majors.

Symptoms of Mathematics Anxiety

To understand how mathematics anxiety interferes with cognitive performance it is helpful to consider the symptoms. These symptoms can be categorized as physiological, mental or psychological, and cognitive. Physiological symptoms include sweaty palms, nausea, head- ache, faintness, and tunnel vision. These symptoms are real, not imaginary. Teachers are usually unaware of the occurrence of these physiological symptoms unless they are reported by the student who is usually well aware of them.

Mental or psychological symptoms include negative self-talk, diminished self-concept, and avoidant behavior. While students are often not consciously aware of these symptoms, the perceptive teacher frequently is. Overt evidence is given by student comments such as those at the beginning of this article. This negative self-talk diminishes performance by consuming large amounts of time and mental energy that could otherwise be devoted to the task itself. Diminished performance confirms negative self-concept and, thus, establishes a cycle that perpetuates the anxiety.

Among the cognitive symptoms of anxiety, three are especially relevant to student achievement in the science classroom. Anxiety: 1) interferes with the ability to remember; 2) decreases the ability to generate a variety of alternatives; and 3) interferes with the ability to rationally choose between alternatives that have been presented. The implications of this cognitive interference for the science classroom are profound. Learning science involves

developing a well integrated conceptual network, generating solutions, identifying relevant methods and formulas, and using these appropriately. Interference with memory, decision making, and solution generation is detrimental to achievement in the classroom. Frequent student comments, such as "I blanked out," "I know how to do this but I just got mixed up," "I used the wrong formula," "I couldn't figure out which formula to use," "I knew this wasn't right but I couldn't come up with another way," should not be taken as mere excuses. They may be valid reports of cognitive symptoms of anxiety.

Intervention

What can you do for math-anxious students when they are in your classroom each week? Avoiding all numbers, charts, graphs, data, and equations is neither an acceptable nor desirable option. But, there are several things you can do. There are teaching strategies you can adopt that are nonthreatening to math-anxious students and enhance learning for all. The teaching strategies listed below are beneficial in creating a low-anxiety atmosphere in the classroom.

Creating a Low-Anxiety Classroom

- Stress conceptual understanding, not memorization.
- Emphasize thought processes, not just final answers.
- Avoid short-cuts that lead to concentration on equations.
- Use concrete materials to teach content.
- Develop concepts qualitatively, then quantitatively.
- Make sure each concept is understood before continuing.
- Give students ample experience solving problems, not just exercises.
- Get students actively involved in the problem-solving process while in class.
- Dispel common misconceptions about math and science.
- Give positive feedback on written evaluation.
- Create a positive, supportive classroom where students are free to ask questions.
- Model problem solving in class.

Modeling problem solving is particularly important since teachers typically present only well-organized, coherent explanations that have been worked out in advance. To model problem solving, you must work out problems in class that you have not previously seen. By doing so, you reveal your thought processes and strategies to your students. More importantly, you demonstrate that problem solving involves exploration, revision, and modification of initial solution plans and, occasionally, starting over.

Beyond the Classroom

Math anxiety is a psychological problem, which in severe cases, needs the attention of counseling professionals. Psychological are not appropriate for use in the classroom. However, you can help your students by diagnosing their difficulty and assisting them in locating programs for the math-anxious or in obtaining professional help. Many colleges have programs designed specifically for math-anxious students. These programs may be located in mathematics departments, in counseling or psychological services centers, or through continuing education divisions. The best of these approaches combine work on the psychological components of math anxiety, such as beliefs, attitudes, relaxation training, and assertiveness training with work on mathematics and general problem-solving skills and heuristics.

If there are no programs available at a nearby college, community service agencies or private counselors may offer pro- grams for the math-anxious. If none of these alternatives is feasible, you might recommend some self-help books to your students. [1,2,3,5]

Everyone profits when a student overcomes math anxiety. For the student, overcoming math anxiety increases career options, paves the way for a better understanding of both academic and everyday mathematics, and facilitates a more confident, assertive, and independent approach to life. For the teacher, benefits include students who can learn science without concentrating entirely on mathematics and who depend less upon rote memory and more upon conceptual understanding. For society, the benefits include not only a potentially greater pool of citizens able to deal with issues of science and technology, but also individuals with a more perceptive view of the nature of learning and of the nature of understanding science and mathematics.

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