MATH ANXIETY IN COLLEGE STUDENTS: SOURCES AND SOLUTIONS

Susan A. Shodahl

Cleon Diers

Sociologist Lucy Sells (1978) discovery in the early seventies that women are more likely than men to avoid courses in mathematics eventually led to a widespread concern with the problem of math avoidance and its probable source, math anxiety. It is now generally recognized that many highly motivated, bright people, including both men and women, avoid courses and activities that involve quantitative analysis. As a result, they severely limit their career options and put themselves at a potentially costly disadvantage in their daily lives. The problem is that it is virtually impossible to totally avoid the use of mathematics, even if it is a simple matter of giving or receiving change, understanding interest rates, or working out a budget. People with untreated math anxiety experience the anxiety in a never-ending cycle of fear, confusion, and defeat (Crawford, 1980). An understanding of the nature and origin of math anxiety is crucial in interrupting this cycle, removing the emotional block, and allowing any math potential that may be present to actualize itself.

Sources of Math Anxiety

The reasons for math anxiety are many and varied. Betz (1977) found in her sample of 655 college students that the students most prone to anxiety were those whose prior math background and achievements were inadequate. Crawford (1980) agrees and suggests that poor math instruction at some point in a person's background may help to create anxieties about math and doubts as to one's own competence. Math instructors must take some responsibility for failing to present material clearly, for their emphasis on exactness, for skipping steps, and for otherwise contributing to the myth that some people have natural math ability while others do not. Our students have mentioned the trauma associated with timed tests, the use of flash cards, and having to solve problems on the blackboard in front of the entire class. Performance anxiety in a math course, even at the

elementary school level, can all too readily become math anxiety.

Both Kogelman and Warren (1978) and Crawford (1980) have also implicated mathematics texts in the creation of math anxiety and math avoidance. Too often such texts are basically unintelligible to the average student. There is often little explanation of process with the result that many concepts are never fully internalized. As a result, students learn to memorize definitions and formulas with little real understanding. Such a strategy for passing a mathematics course may work up to a point (for example, up to elementary algebra), but beyond that point the system begins to break down. For some students, math anxiety does not begin until they attempt to take higher level math courses. Many are surprised and dismayed to find that they are not the good math students they thought they were.

Renner (1976) has suggested that these students may still be functioning at what Piaget calls the level of concrete operational thinking. The concrete operational thinker is concerned with concrete objects, events, and situations, and does not formulate hypotheses outside of his or her realm of direct experience. The formal operational thinker, on the other hand, can stretch thinking beyond reality and into the realm of the possible. A person at this level can cope with the abstract propositions and ideas characteristic of higher-level math. Renner speculates that some 50% of students entering college are not yet fully formally operational in their thinking. Mallow (1981) in his investigation of the related problem of science anxiety, suggests that what Piaget thought was a natural transition from concrete to formal operational thinking is really neither so easy nor so natural. Teachers must provide students with the kinds of experiences that will aid them in making this transition. Renner sugested that traditional classroom instruction, which does not encourage personal student investigation and discovery of concepts and ideas, actually retards the movement of students through the cognitive stages identified by Piaget.

In addition to being geared to the level of concrete operational thinking, the American educational system is heavily left brain in its focus. Research in the area of brain functioning suggests that the two cerebral hemispheres are specialized to operate in different modes (Ornstein, 1977). Where the left side of the brain is verbal, holistic, and relational. Our educational system tends to utilize left brain functions more than right brain functions. The math student, for example, is trained to move in a step-by-step manner in solving problems, certainly an important component in math but not the only one. The student is not encouraged to develop the overall picture or to trust his or her intution. Logic (the left brain) is emphasized at the expense of feeling or intuition (the right brain). Visual-spatial skills, which are heavily right brain and which seem to play a part in the attainment of a fuller understanding of mathematical concepts, also tend not to be developed (Maccoby & Jacklin, 1974). Educators obviously need to pay more attention to the relationship between levels of cognitive development and teaching techniques.

Given these conditions of early math education, it is easy for a student to miss an important step or concept along the way. Once this happens, the problem escalates at an alarming rate and the student falls further and further behind. Math may become a source of great stress, confusion, and a sense of loss of control. The end result may be an impaired self-image, leading inevitably to increased anxiety about math and to math avoidance.

Contributing to this anxiety are a number of math myths identified by Kogelman and Warren (1978)—that there is only one way to do a problem; that you must be able to solve problems quickly in your head; that you must always know how you

got the answer; that math requires logic and not intuition; that men are naturally better in math than women. With these sorts of restrictions on our thinking, it is no wonder that so many Americans are suffering from math anxiety. Such false assumptions help to create, perpetuate, and maintain high levels of anxiety about math.

Our adult behavior is the product of our early socialization experiences. We very early begin to develop a self-concept that includes an evaluation of what we can do well and what we cannot do well (or at least what we think we cannot do well). We begin to develop expectations of success and failure and the self-fulfilling prophecy begins to operate. Many people develop expectations of failure in math for some of the reasons already mentioned, frequently followed by actual failure experiences that serve to validate the expectation. Studies have shown that the successful solution of math problems has more to do with one's attitude and feelings about math than with any innate aptitude (Crawford, 1980). The person with the negative self-image is predestined to do poorly in math. Something needs to happen to break up this self-defeating cycle. The something we have made happen is a course called Math Without Fear.

Reducing Math Anxiety

Our Math Without Fear course is a one-unit, non-transferable, semester-long course which meets once a week in a two-hour block. It is co-taught by a psychologist (in this case, a woman) and a mathematician (in this case, a man). At the first meeting, the students are informed that the course is not a math course, that they may be at any level of math proficiency, and that they do not have to be concurrently enrolled in a math course. Rapport-building is the first major order of business. The instructors present themselves as supportive and understanding people who recognize the problem of math anxiety. The students are encouraged to share their backgrounds and their experiences in math in the hopes of developing a support group atmoshpere. Since past experiences with math seem to contribute so much to the difficulty, students are asked to fill out a math autobiography as a way of bringing the relevant memories and feelings back to life. These memories are discussed in the group at the student's discretion—no one is put on the spot or forced to contribute. The students are also required to keep a weekly journal in which they are asked to respond to the reading assignment (chapters in a math anxiety book) in a personal way and to jot down any experience with numbers they might have had during the week. These experiences are then discussed in the group. One of the objects of this assignment is to increase their awareness and appreciation of the operation of math in their everyday lives. Another goal is to elicit questions about mathematical concepts which the math instructor can then explain in a clear, down-to-earth manner. An unexpected but thoroughly gratifying side benefit of this exercise has been the support and actual advice given by members of the group to any individual member who voices problems with frustration, depression, and a sense of loss of control. In such instances, peer influence has more of an effect than any words of encouragement offered by the instructors.

A few weeks into the semester, the students are introduced to relaxation exercises. Music specially designed for relaxation is played while the students practice diaphragmatic breathing, progressive muscle relaxation, and guided imagery (Halpern, undated). These exercises are practiced in class for the rest of the

semester and the students are encouraged to use them on their own as well.

Where appropriate, guest speakers are brought in to further validate the points being made in class. Successful professional people talk about their experiences with math anxiety and the techniques they used to cope with it successfully. Former Math Without Fear students do the same with remarkable impact on the students who are still working to reduce their anxiety. A vocational counselor discusses the career options open to those who have a good math background. An acupressure expert describes ways to relax using acupressure.

The nature and history of math are discussed in an attempt to remove some of the mystery which tends to surround it. The math myths are shown to be merely myths. Blocks to problem-solving are discussed, as are ways to go about solving problems efficiently and successfully. Students are given math games to play in an attempt to show them that numbers can be fun. Various mathematical concepts are presented in a hands-on, visual way in order to encourage more right brain perception of the concepts and hence a fuller understanding of the concepts—cutting out factors, geoboards, attribute blocks, and tangrams are a few of the techniques used. Throughout all of these activities, the students are encouraged to ask questions, to voice their feelings, and to think positively. They know that the evaluation of their performance in the course is more a matter of active attendance than the quick solution of math problems or even the elimination of math anxiety.

Results

Although the course is called Math Without Fear, our goal is not to somehow miraculously remove all vestiges of anxiety regarding math. Our more realistic goal is to teach the students to manage their anxiety in such a way as to help them get beyond the mental and emotional blocks that are preventing them from actualizing whatever math potential they might have. Data, both formal and informal, from the 40 students who have taken our course so far, suggest that we have been successful in reaching this goal. When asked whether or not the class was helpful to them, students responded with an average rating of 9.1 on a 10-point scale (10 being the highest rating). A comparison of pre- and post-test scores on the Mathematics Anxiety Rating Scale (given at the beginning and at the end of the semester) indicated a substantial decrease in perceived math anxiety (Suinn, 1972). From an initial mean of 311.3 points (range: 0, no anxiety, to 490, extreme anxiety), there was a decrease to a mean of 213 points at the end of the semester.

At this point we would like to be able to provide data regarding the subsequent math activities of our students but empirically sound follow-up studies are difficult. An informal survey of transcripts yielded the following. Of those who were enrolled in a math course as well as the Math Without Fear course, 83% successfully completed their math course. Of those who subsequently enrolled in a math course, 56% successfully completed the course.

But even more information than these measures are the written comments of students regarding the impact of the course in their lives. For most of the students the course did not simply alter their attitudes and feelings about math. In fact some of them noted that they still felt some anxiety about math but that they no longer felt immobilized by the anxiety. The majority indicated an increase in overall self-confidence and in their ability to manage anxiety in a variety of situations. There was general agreement that the relaxation exercises and the support group atmosphere of the course provided them with the opportunity to experience a

greater sense of personal control over their own reactions. Since our goal was not to eliminate math anxiety but rather to lead students to a recognition of the emotional blocks regarding their ability to do math, we are more than gratified by the results of our efforts.

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Susan A. Shodahl is Assistant Professor, Psychology, San Bernadino Valley College, San Bernadino, California.

Cleon Diers is Assistant Professor, Mathematics, San Bernadino Valley College, San Bernadino, California.