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ABSTRACT

As colleges take on increasing numbers of nontraditional students who have had only minimal exposure to mathematics, instructors must alleviate patterns of math anxiety and math avoidance which impede academic success, and, in a technological society, limit career opportunities. Among the obvious causes of math anxiety are: instructors' insistence on the right answer; the need to perform math skills with speed; and the fact that math knowledge is cumulative. Less obvious factors are: the defeat experienced when a student cannot master the next highest level of math skills; the myth that some people are not "mathematically minded"; and the inability of some students to handle frustration. Still another dimension of math anxiety is the low math self-esteem of many women. Research shows that while there is no difference between men's and women's math ability, many women believe that men are more mathematically capable. Given these anxiety patterns, math instructors must concentrate more on enhancing students' self-confidence. While some may argue that the introduction of anxiety-reduction techniques may water down course content, a study at Middlesex Community College (CT) has demonstrated that students experiencing such instruction continue to higher-level math courses more often than students in traditional courses. (JP)

MATH ANXIETY AND THE STUDENT OF THE '80's.

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Pat Cross, author of Beyond the Open Door, speaking at a developmental education conference in Lexington, Kentucky, gave an excellent model of the student population of the '80s.

A group of people in individual cars being met by a traffic cop at an entrance to a superhighway and escorted to the next exit, ten years ago had no problem. Of twenty cars, seventeen were going 70 mph, two at 45 and one at 30. In the intervening years, higher education has been building new accesses to the superhighway, and today the same traffic cop is still taking, or trying to take, twenty cars to the next exit. But now the makeup is different:

-- two cars are without wheel alignments
-- three have drivers with erratic driving habits
-- two don't want to go the exit
-- three are out of gas, and no money
-- two have never been on a superhighway and are scared to death
-- three drive classy antique cars and want to take time to look at the scenery
-- and four want to go 60 mph

There is no way we can change these new groups into the old "traditional" ones, and I, for one, wouldn't want to; but our survival as institutions depends on how well we accept the challenge of this diversity.

Taking a more formal look at the student of the '80s, according to the latest Carnegie Report on Policy Studies in Higher Education:

> By the year 2000 post-secondary institutions will enroll more women then men, as many people over 21 as under, and nearly as many part-timers as full-timers. The traditional college-bound group of 18 - 24 year olds will have declined by 23 percent. The impact will be offset by increases in participation by students 25 or older, by women, and by members of minority groups.[1]

> Students will be recruited more actively, retained more assidously, graded more considerately, financed more adequately, taught more conscientiously, placed in jobs more [illegible]. The curriculum will be more tailored to their tastes.[2]

But at the same time the A.A.A.S. sees [illegible] for the sciences and engineering in a state of real crisis:

> Only about 1/3 of the high schools require more than one year of mathematics or science for graduation. Moreover, as society becomes more dependent on technology, technically illiterate students may be forsaking the ability to be fully productive citizens in many walks of life.[3]

In other words, students of the '80s, while they see mathematics as a requirement of every discipline, -- the computer encroachment, even in art and language, for example -- will be coming to tertiary education with only the most basic understanding of mathematics and, for too many of them, a pattern of math avoidance and anxiety which makes career choice, career change, or career update a threatening thing indeed.

Why does this pattern exist, and what can be done about it? The why's have been thoroughly explored in books like Sheila Tobias' Overcoming Math Anxiety and Kogelman and Warren's Mind Over Math, so I will only touch on them briefly.

First of all, there are the obvious reasons. There is the insistence on the right answer. 5 + 8 is not more than 10 or less than 15; it is exactly 13. And second, a reasonable degree of speed is necessary if the skill is to be of much use. Thus, early, the gold stars go to those who get the answer right and fast, and feelings of helplessness and hopelessness become associated with numbers for too many young children. Add to this the fact that mathematical knowledge is cumulative: if you can't add, you can't subtract or multiply, and if you can't subtract or multiply, you can't divide, and without all four, fractions or decimals are impossible and you get a feeling of how difficult and frustrating these first stages of mathematics can be.

Of the less obvious reasons, three seem to be of particular importance. The first is the "sudden death" experience. It does not matter at what mathematical level it occurs. Suddenly a concept is too hard to understand and although it is simply the next step in a developing process, it is as if a "curtain had been drawn," "there was a wall ahead," a "drop-off" or a "steep cliff," and the student has the feeling he will never be able to understand this particular process or concept. It will be useless to try. Unfortunately, along with this goes the feeling that everyone else understands. In this situation the student will not ask a question, so there is no way out of the dilemma. They feel guilty and ashamed, and never consider the possibility that it may not be all their fault.

Contributing to this feeling of helplessness is the common mythology about mathematical ability -- the mystique of the mathematical mind. While creative mathematicians, like creative people in all areas, have special talents, there is not satisfactory evidence that ordinary people with the ability to do college-level work in English, psychology or biology are not cognitively able to do mathematics to the calculus level. No teacher of history ever told a student who wrote a poor exam or passed in an inadequate term paper that he didn't have an historical mind. Yet such is the mysticism about mathematics that teachers, parents, counselors, and peers all cling to the idea of some sort of genetic predisposition as the only sure guarantee of survival at any level.

The second reason is the verbal ambiguities which particularly frustrate the verbally gifted student: "multiplication" of fractions, which results in smaller ones; "dividing," which results in larger ones; "adding" negative and positive numbers, when you are actually "subtracting," or "subtracting" when you are "adding." A reaction which continues to surprise me occurs early in each developmental class. I ask how many feel that mathematics is not logical, and at least 75 percent of the class raise their hands! A good friend, a fine history teacher, recently related to me an experience he remembered, -- a further example of the "illogic" of mathematics. In second grade he was told that you always subtracted the smaller from the larger; so, given an example 92 - 17, he subtracted the 2 from the 7 and the 1 from the 9 and got the answer 85. He still resents the teacher's reaction. Thus the verbally gifted may turn away from mathematics precisely because it is not "orderly". . .at least as far as language is concerned.

The third reason is the inability to handle frustration: not frustration in general, -- students often handle frustration very well in other areas, -- but only as it occurs in mathematics. In talking with them about this, I find that they will agree that in writing an English paper, for example, they will leave it if a paragraph is not going as they wish, recognizing the need to take a fresh look at it later, but the math example must not be left until it is done; therefore, if they do leave it, it is with extreme feelings of frustration. Certainly one difference between the math anxious and the math able lies in this reaction to frustration. It is something the psychologists call "focus by failure." Does the student say: "No more, never again. I always knew I couldn't do it." Or does he accept the challenge? I see the anxiety caused by frustration on a continuum: on the one side creative, on the other destructive. Creative frustration serves as a spur; destructive closes the door.

At this point it may be useful to look at some of the reasons that women's mathematical self-esteem is lower than men's. John Ernst, a mathematician and teacher of statistics at the University of California in Santa Barbara, in 1973 conducted a study which is reported in his article "Mathematics and Sex." He found that young women in his elementary and secondary school sample showed no greater liking or disliking for mathematics than young men, although when asked what subject they liked best, girls were more likely to name English and boys science. However, when mathematics became optional, fewer girls than boys elected to take these subjects. Ernst concluded that it was role expectation and not native ability that made the difference.

> Men take more mathematics not for the superficial reason that they like mathematics more than women, but because they are aware that such courses are necessary prerequisites to the kinds of occupations they envisaged for themselves.[4]

Another finding is that from sixth grade on, as the father becomes the family authority in mathematics, it is to the father that children of both sexes go for homework help in math. Thus, the degree of interest a father takes in his daughter's intellectual development may determine her attitude toward math and her success in overcoming negative pressure from friends and teachers. There is a study which shows that for a girl to be math able she must be close to her father, have no brothers, and be foreign-born!

Elizabeth Femina's studies in Wisconsin show that, given the same mathematics exposure, there is no difference between young men and women in mathematical ability. The Johns Hopkins study seems to show young men better than young women. Alan Natapoff at the University of Massachusetts is in the process of a study which seems to show that little girls, more able to abstract at an earlier age, are held back in the first three grades until the little boys are ready, and by this time they are bored with the emphasis on mechanics; therefore, the very fact that they are better sooner may react against them in later mathematical development.

There is no question that teachers and students of both sexes believe that men do better in math than women. Even bright women believe this to be so. When men do poorly in math, they explain their failure by stating that they didn't work hard enough, that the teaching was poor, or that it was just bad luck. Women who fail are three times more likely to attribute their failure to the "fact" that they simply can't do math. So if men think men do better in math, and women think men do better in math, and teachers and parents think men do better, is it any wonder that men do better?

For seven years I have been actively involved in trying to help students deal with the problem of coping with mathematics, as coordinating teacher of Wesleyan University's Math Anxiety Clinic and as a member of a mathematics department at a community college. It is my contention that simply force-feeding additional or missing mathematical knowledge is not the answer for students with long histories of unfortunate mathematical experience. Rather, self-confidence must be increased and anxiety reduced before learning can proceed at a conventional rate.

As a model, I use the idea that as I cannot teach you to swim until you relax and trust me and know that I am not going to get you in deep water and withdraw my support, neither can I teach mathematics to these non-traditional students until they relax and trust me and realize that I will never say: "That's a stupid question. I've already answered it twice and you should have known it anyway."

We spend as much time as necessary discussing feelings and how to deal with those feelings. I impress on them Sandra Davis' Bill of Rights for the Math Anxious - in slightly garbled form:

I have a right to:

Learn at my own pace
Ask questions
Need help
Ask for help
Not understand
Say I don't understand
View myself as capable of learning math
Evaluate my teachers
Be treated as competent
Define success in my own terms.[5]

A most respected friend and colleague, Miriam Hecht, of Hunter College in New York City, says that all that really matters is the humaneness of the teacher, and I certainly agree that this is of utmost importance. A traditional student whose teacher has enthusiasm for his subject and concern for his students is certainly in a fine learning situation, but in my opinion, for the non-traditional students we must go one step more. -- We must help them face and change their attitudes toward mathematics in order that real learning can occur.

As anxiety reduction techniques are finding their way into developmental math classrooms everywhere, serious questions are being raised as to the effect this is having on the mathematics being taught in these classrooms. "Is the mathematics in these classes being watered down?" "Is subject matter being replaced by psychology?" "Are the students being spoon-fed?" "How do they survive in a 'real' math class?"

In an attempt to answer these questions at my own college, I set up a research project to compare the records of my anxiety reduction classes and those taught by more traditional methods in three areas:

1. Attrition vs. retention in developmental classes
2. Number who take another math course after completion of the developmental course
3. Marks in these following courses.

I am a member of a five-person mathematics department in a community college in Connecticut. All of us share an enthusiasm for mathematics and a concern for our students, but I am the only one who actually uses anxiety reduction techniques in the classroom.

For my study I took all sections of our developmental course from spring semester, 1977 through fall semester, 1980: a total of 1,105 students.

For area 1: Recorded W's and I's. added them and found percent for the anxiety reduction classes (24.7 percent), and for non-anxiety reduction classes (36.2 percent). H_0 : Percent of withdrawals + incompletes is the same in both groups. H_A : Fewer withdrawals + incompletes in anxiety reduction classes. Using the standard error of the difference-between two percentages, the null hypothesis was rejected at better than the .01 level (z = 3.83).

For area 2: Using the students who finished the course (leaving out withdrawals, incompletes, and those from the fall, 1980, as there was no follow-up data on them), recorded those who took another math course. (53.2 and 46.9 percents) H_0 : Percent who took another math course is the same for both groups. H_A : More in the anxiety reduction classes. Using the standard error of the difference between two percentages, the null hypothesis was rejected at the .05 but not the .01 level (z = 1.31).

For area 3: Recorded marks in all follow-up math courses taken, assigning A : 4; B : 3; C : 2; D : 1; F, W, I : 0. H_0 : The pattern of marks for the two groups was the same. H_A : The pattern of marks was different. Using the Kolmogorov-Smirnov largest-sample 2-tail test, the null hypothesis was not reject at the .05 level (.180). (D = .057). Because I was surprised at this result, I checked the significance of the difference between means of the two groups, using standard error of a difference between means of large groups, after checking the F ratio for homogeniety of variances. The resulting difference between means was not sifnificant. (z = 1.03).

In conclusion, this would seem to indicate for my college that of those students who have been helped to use anxiety reduction techniques in dealing with the problems of coping with mathematics a significantly larger percentage take another math course and show no significant difference in their ability to cope with traditionally-taught, higher-level courses.

Math anxiety and the student of the '80s: The anxiety is still going to exist. It's going to be prevalent. But there _is_ something we can do about it!

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