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ABSTRACT

"Math anxiety" can be a lifelong stumbling block affecting the student's level of performance and willingness to go beyond the minimum courses required, and hindering career change or advancement. The cumulative nature of math learning, early insistence on the right answer with reasonable speed, paranoia that not understanding will result in ridicule, the mystique of the genetically-predisposed mathematical mind, and inability to handle frustration when dealing with math are a few sources of math anxiety. Women are further handicapped by the stereotype that they are unable to excell at math because of their sex. A math anxiety clinic at Wesleyan University helps students reduce anxiety and increase self-confidence. A non-threatening environment is set by an initial interview which examines the student's degree of fear and his or her goals for the future. In class, individual strengths are stressed, and the fact that there is no best way to work a problem is repeatedly demonstrated. Problem-solving in small groups is extensively utilized to make math a social experience. The students evaluate their progress at mid-semester. The final exam is a standardized multiple-choice form to give the students practice for various standardized placement tests. A similar program has been implemented in developmental mathematics classes at Middlesex Community College. (DD)

Anxiety Reduction in the Developmental Mathematics Classroom

By

Jean Burr Smith

Paper presented at the Invitation to Innovation Conference, March 29-30, 1979

ANXIETY REDUCTION IN THE DEVELOPMENTAL MATHEMATICS CLASSROOM

I speak from a totally prejudiced point of view. In spite of a love affair with mathematics, which started for me at about age 7, I see mathematics as the primary root of all the evils which beset students in their search for a career, career change, or career up-dating. Mathematics with flash cards and insistence on the right answer fast which scares them at age 6 plus, mathematics that our culture insists is not for girls at age 13, and, finally, mathematics which turns out to be required for at least 75% of the careers when they are faced with making a career choice at 18 or 28 or 38.

At Wesleyan, four years ago, we decided to do something about it. We felt, and still feel, that simply teaching the same math better is not enough. The student must be helped to face why he feels the way he does about mathematics, what difference those feelings make, and how they can best be dealt with. This is why from the beginning there have been two components in our program, the psychological and the mathematical, not separate out interwoven, and this is why we have emphasized the word, "math anxiety".

Robinson and Swinn in a study in 1972 defined math anxiety as "feelings of tension and anxiety that interfere with manipulation of numbers and the solving of problems in a wide variety of ordinary life and academic situations".

As examples of what we are talking about, here are two letters, the first from a high school junior:

"I am writing for your help concerning my profound difficulty in math.....I was very glad to hear about you. This summer I'm studying for my college entrance exams, which I shall take in the fall. My mathematical ability is sure to cripple me.....my present level is very low. I can add, substract, do some basic multiplication and division, but I don't understand anything much beyond this, such as fractions, decimals, 'pie', root-figuring, area, etc. Can you help me. I seek an instruction book which can help me with my 'phobia'. It's not an anxiety trip. It's just that numbers seem to distract me from my relaxation."

and this one from a freshman:

"This year was probably my last year of math because in my school you only need one credit of math to graduate. I've had a tutor in math for the last three years but this past year was the very first that someone took the time to teach me fractions. I

was so happy. Sometimes I still panic when I see fractions but at least I know how to do a lot of them....." She enclosed several math jingles she had written. My favorite is:

"Watching a decimal
Change to a fraction
Seems to a math teacher
A feature attraction."

In actuality, I no longer try to define the phrase. I simply say, "If you don't know what it is, you don't have it." I could fill pages with response from people who know. Probably the most startling was from the young electrical engineer who took us through the atomic plant in Scotland. His reaction was, "Will you please explain logarithms to me? I've never understood them." It turned out he had never made any connection between a logarithm and an exponent!

Whatever it is, this anxiety affects the student in two ways - level of performance within the required class and amount of mathematics taken beyond the required minimum.

Why is it? First of all there are obvious reasons. There is the insistence on the right answer - 3 + 7 is not more than 8 or less than 12. It is exactly 10, 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 the feelings of helplessness and hopelessness become associated with numbers for too many young children. Add this to the fact that mathematical knowledge is cumulative - if you can't add, you can't subtract or multiply, and if you can't subtract and multiply, you can't divide, and without all four fractions and decimals are impossible - and you get a feeling of how difficult and frustrating these first stages of mathemathics can be.

Further and less obvious reasons are developed by Sheila Tobias in her book, Overcoming Math Anxiety, and of these, three seem to me of particular importance.

The first is the "Sudden Death" experience. Students in the clinic describe this experience in much the same way regardless of the mathematical level at which it occurred. Suddenly a concept was too hard to understand, although the concept may be simply the next step in a developing process. It was as if a "curtain had been drawn". "There was a wall ahead" or a "drop off" or "steep cliff" and the student had the feeling that he would never be able to understand this particular concept - that it was useless to try. Along with this feeling of hopelessness is

one almost of paranoia - that everyone will find out how little they know and how they really never understood. In an effort to cover up these feelings of failure, they will not ask questions 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 no satisfactory evidence that ordinary people having 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 did not have a historical mind, yet such is the mysticism about mathematics, that teacher, parents, counsellors, and peers all cling to the idea of some sort of genetic predisposition as the only sure solution to 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" positive and negative numbers when you actually are "subtracting" or "subtracting" when you actually are "adding". The only way to survive in such a world, they tell us, is to memorize; logic just doesn't apply.

Knowles Dougherty, a skilled teacher of mathematics notes,

> It is no wonder that children have trouble learning arithmetic. If you ask an obedient child in the first grade, "What is zero?" the child will call out loudly and with certainty, "Zero is nothing". By the third grade he knows that zero is a place-holder and if by the 5th grade he believes that zero is a number that behaves like other numbers, he is in for trouble.....

An experience in one of my classes this spring convinces me that this first grade confusion continues. In discussing the slopes of horizontal and vertical lines, we looked at slopes of 8/0 and 0/8. My class assured me that since "one was nothing and the other zero" obviously the slopes were the same!

A good friend had the last word in a letter she wrote after a long conversation in which I tried to persuade her that mathematics was rational: "I have no math anxiety, just suspicion. I am literary oriented. The math vocabulary makes me uneasy. 'Improper'

and 'irrational' seems that some numbers need censure, and how do you know which are good ones and which are not socially acceptable? And 'X' also seems to mark the spot, - vaguely criminal."

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 dealing with 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.

Math students, however, are not just low in tolerance for frustration. They very often handle frustration very well in other subject areas, but there is a particular aspect of the frustration they experience in doing math that makes them freeze. Whatever this is, it causes them to have an intensely emotional reaction to math.

One way to begin to deal constructively with this is to introduce the student to his or her own frustration. By keeping a diary or talking into a tape recorder, the student may begin to recognize that he creates his own pattern of resistance and, with luck, he may soon learn to control his low tolerance for frustration. One excerpt from a math diary is a case in point.

> "Here I go again. I'm always ready to give up when the equation looks like it's too complicated to come out right. But the other week an equation that looked like this did turn out to be right so I shouldn't be so depressed about it."

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. To me, this challenge has always been the joy of mathematics; the feeling that it's there to come back to, that there is no need to finish it in one sitting and I see the anxiety caused by frustration on a continuum. On the one end creative, on the other destructive. Creative frustration that serves as a spur, - destruction that closes the door.

At this point, it may be useful to look at some of the reasons that girls' self-esteem in mathematics is lower than boys. At about the same time that Luch Sells was studying freshmen and women at Berkeley, John Ernest, a mathematician and teacher of statistics at the University of California in Santa Barbara, was noting that his women students suffered severe mental blocks in learning statistics. When in 1973 he was given the opportunity to teach a freshman seminar on the subject of "Women and Mathematics", he sent his students out into neighboring schools to probe pupil and teacher attitudes toward female competence in mathematics. The results of 1,324 questionnaires are reported in his article "Mathematics and Sex". Ernest's team discovered that girls in his elementary and secondary school sample showed no greater liking or disliking for mathematics than boys, although when asked which subject they liked best, girls were more likely to name English and boys science. However, when mathematics became optional in the higher grades, fewer girls than boys elected to take these subjects. Ernest 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 future occupations they envisioned for themselves."

Even more interesting is another finding that from the sixth grade on, as the father becomes the family authority in mathematics, it is to their fathers that children of both sexes go for homework help in math. Thus, the degree of interest the father takes in his daughter's intellectual development may determine her attitude toward math and her success in overcoming negative pressure from her 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!

There is no question that teachers and students of both sexes believe that men do better in math than women. Even bright women presume this to be so. When men do poorly in math, they explain their failure by stating that they did not work hard enough, or 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 the men think the men do better in math, and the women think the men do better in math, and teachers and parents think the men do better, is it any wonder that men do better?

To attempt to deal with these long-standing problems, a math anxiety clinic was established at Wesleyan. Since it was never our intention to force-feed additional or missing mathematical knowledge but rather to increase self-confidence and reduce anxiety so that learning could proceed at a conventional pace, we first of all tried to establish a non-threatening atmosphere. For this reason the student's first contact with the clinic was an individual interview with a counsellor designed to set the tone of the clinic. Here the student was encouraged to talk freely about his or her reasons for deciding to come for help. Bonnie Donady, coordinating counsellor for the clinic, developed the strategies for the interviews. Anyone wanting detailed description of these strategies should write to her at the clinic.

In general, the interview covers these areas:

1. Personal goals in terms of math.
2. Past math experiences, positive, negative and recurrent.
3. Confidence level and percieved ability in dealing with math and the frustrations of learning math.

For the student with low or no anxiety, but some avoidance, the decision to take math again is relatively easy. Perhaps it is apparent that now they want to take courses that require useable math skills. If they feel that their skills are inadequate or rusty, they are grateful for the opportunity to retool and increase their options. These students may have allowed math to work as a filler before but are no longer willing to do so. Academic major or career plans made in high school are no longer viable.

The next type of student describes herself as not really anxious ("I'm not scared of it") but rather merely not confident about math. She continues by saying she didn't feel as if she really knew what was happening in math and memorized a lot. At the point of the initial interview there are no plans other than the entry level course.

For the very math anxious, those who see themselves as hopeless in regard to math and math related subjects, the common request is, "I want you to make me feel good about math" or "I decided to see if anything really could be done for me". When these people are asked to complete the sentence, "If only I could do math, then I would....." The answers range from, "I'd go to medical school" to "then I'd know it all, I'd really be competent".

The final sections of the interview focus on the individual's estimation of potential

mathematical success. The counsellor asks or listens for answers to:

1. What were the successful experiences?
2. Does the person acknowledge or minimize them?
3. Does the person remember feeling confident then?
4. How does she feel now about her ability to begin again?

As the answers to these and other questions are examined, the areas of focus emerge. One woman described her former confidence as the time when she was not merely "plugging in formulas", but had a sense of the problem.

Some will readily agree that there have been bad English or Social Study teachers but somehow this did not affect their belief that they would be able to read or learn history effectively. Math, on the contrary, was seen as accumulative and sequential; one bad year could ruin the rest.

The math anxious must become very aware of what they are feeling and what messages they give to themselves. If they minimize their success, they have placed themselves in a "Catch - 22" situation. "If I can do it, it isn't real math; if I can't it proves what I have been thinking all along - I never would be able to do it." The person who continues the "Catch - 22" may also have been involved in a cover-up even though he had good grades, internally he felt that he did not really understand the material and his goal was to make sure that no one found out the truth before he had the chance to stop taking math. The corollary of the cover-up is that everyone else understood it.

With the interview over, my part as a teacher with a good bit of experience with and concern for the mathematical non-achiever begins. It has been my great good fortune, these past four years, to have two interweaving jobs. As the person in charge of the teaching of the clinic courses, I have taught the group of 7 - 9 who, by interview, seem the most anxious and by placement, test the weakest in skills. At the same time, I teach in the math department in the local community college where in our math 99, a for-credit developmental course, I have similar groups of people in classes of 25 - 45. I try things at Wesleyan and when they work, I apply them at Middlesex.

First, and most important, is the atmosphere in the classroom - we talk about feelings. In the small class, this is very easy.

The math anxious are eager to share their feelings. In the large class, of course,

this is not easy. In the beginning when our schedule allowed it, I had a psychologist come in and talk with them about anxiety in general and math anxiety in particular. "How do you feel when you go to the dentist." "How do you feel when you walk in this classroom?" And two things always came out in the general discussion. At least half the class is sure that understanding math is impossible for them and that they don't like the answers in the back of the book. They are so sure these answers are wrong, they don't want to check! I have them fill out my first hand-out as the first assignment and this gives me direction for more talk about feelings. Any time spent in helping them to relax is time well spent. As an analogy, I could never teach anyone to swim until the person trusted me knew that I would not let go of them in deep water, and relaxed. Similarly, I cannot teach them mathematics until they are comfortable with me.

I stress from the beginning what I call math-by-committee, working together in small groups. I do this for two reasons, students are much more likely to ask questions or volunteer answers as part of a group but, even more important, none of these students have ever realized that doing math can be a social experience. The first test of the semester is done by the committees.

I lay the ground rules the first day, passing out a very detailed outline. Homework is passed in, and checked. Attendance is at the discretion of the student. Tests must be taken on the designated day but retakes may be taken as often as necessary to get the desired mark. A student may be delighted with a C or take a test four times to get an A. At Middlesex we have a math lab where the students take their retakes. The possibility of retakes seem to reduce the test anxiety and by the middle of the semester very few are needed. They may bring any information they need to tests on a 3 x 5 file card. As I tell them, I am testing them on how well they use information, not on how well them memorize and I encourage the use of hand calculators.

We do word problems constantly. No one at this level is taking a math course simply to add, substract, multiply and divide. They need to be able to use these skills. We found, to our surprize, at Wesleyan, that because we did word problems every day, the students came to look forward to them and did them first on tests and on the final, and I now find this true at Middlesex.

From the beginning we emphasize that there is no best method. I write down any answer that anyone suggests and apparently have gotten very good at not showing preferences. Then we look at how each answer is gotten. We develop the idea that there are no wrong answers - only wrong questions. The student answers the question as he or she hears it. It is the teacher's responsibility to discover the question the student is answering in order to reword the original question.

Thus with a variety of word problems we can discover individual strengths and weaknesses.

Take these two:

1. A cube is painted red and then with six slices is cut into 27 equal cubes. How many have one side painted red? How many none?

2. A $200 stereo is advertised at a 20% discount. Should I have the clerk figure the discount first or the sales tax?

Each of these will turn up several solutions, but they will also show which students can visualize, which prefer calculations and which can do neither.

Usually in the second week we do the math reading test. This must be done in groups so that no one is made to feel ridiculous in front of the whole class.

At mid-semester I pass out the second math anxiety sheet and we talk about the good things that have happened and the things that are still not so good. As one student said, "I can do most of the examples now but I've never gotten one done first."

I give a standardized final at the end and next year I intend to put multiple choice questions in the homework assignments and in the period tests. For many of them, these will prepare them for the selections in which their math skills will be recognized - for jobs, or job improvement - or in the Grad Rec, the MCAT and the LSATS for many of the non-traditional students, as with my class of boys.

I've adopted many of the ideas of colleagues:

1. Have the class appoint a dummy-of-the-week so that any one with a question he or she doesn't dare ask can write that question down and give it to the dummy-of-the-week for asking!

2. Give unsigned quizes. You don't care who knows the particular piece of information , just want to know how many do. This will open your eyes to quiz anxiety!

3. Have students mark questions on a test on an anxiety scale of 1 - 10. This is a good critique of your questions.

4. In taking tests, tell students to allow themselves 5 minutes to panic by the clock. Most people can't stay panicked that long. Then look through the test and pick a question to try and fold the test so they see only that question.

5. As a change in attacking word problems, don't read it all through first - translate phrase by phrase into symbols, then fit the phrases together.

6. Have a naming day and give everyone who can name everyone in the class 10 points. Knowing names is extremely important, both for you and the students. As John Roueche says, "Many persons come to class sure of only one thing, their own name, and you must make contact early or lose them.

7. Use values clarification techniques. For information on these, write David Blauer, Math Dept., State University of New York, 1300 Elmwood Ave., Buffalo, New York 14222.

One other effort we have made to deal with math anxiety is in working in a team, counsellor and math teacher with small groups in a series of 4 or 5 sessions. Here we do math only incidently to help the participants become aware of their feelings, face these feelings, and decide what to do about them. This spring, we ran a pre-registration group helping students to decide whether they would dare take a math course next semester and, if so, which one.

In the first session, we talk about feelings and when and why the bad feelings started. During the first week they are asked to keep logs of good and bad mathematical experiences and we talk about these at the second meeting, listening for the messages they give themselves. The third and fourth meetings vary with different groups, but in each they have become very supportive of each other and each person involved has gone on to take a quantitative course if not an actual mathematical one.

As I said in the beginning, this past year I have taught a special class in New Haven, and out of this has grown my latest concern - a two semester math course for the highly verbal, non-traditional student, a course which I call Reentry Mathematics. In the first semester we emphasized the anxiety reduction, reviewed the basic operations in arithmetic and algebra, emphasizing the applications in word problems and introduced graphing. In the second semester we covered linear programming for decision making, probability for statistics and an intellectual understanding of the two operations of calculus. It was an unbelievably exciting experience, and I am convinced there is a population waiting for such a course.

In closing, let me quote from the conclusion of the Hartford Courant reporting on a workshop I had done with elementary teachers. "Mrs. Smith says one way to help

cure math anxiety is to take another math course and try to overcome old hang-ups.

I can't - I'm afraid some mean imaginary number in its fractional form will show up in a train A train B problem causing me to panic and reveal my ignorance to the whole class.

It's not math anxiety. It's stark unadulterated math terror."