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Mathematics anxiety: A study of its causes as proclaimed by educational research

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by

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In today's fast-paced, high-stress society, feelings of anxiety have become commonplace; even normal. Of the many anxieties that have been found to affect people, one that I, as a future math teacher, have become very concerned about is mathematics anxiety (also called mathphobia). Even now, during my college career, I have noticed an alarming number of people around me (colleagues, co-workers, relatives, roommates, etc.) who claim to be "terrified" of math. Listening to their explanations as to why they find math so threatening has made me realize the importance that math anxiety will have in my career.

For these reasons, I have chosen to investigate several researchers' theories which attempt to explain the causes of math anxiety in students in hopes of being better able to understand and help my future students. I would also like to describe several methods that have been developed to test students for math anxiety.

What is Mathematics Anxiety?

Different researchers emphasize very different aspects of the characteristics, causes, and effects of math anxiety in their definitions of it. One very well-known definition from Richardson and Suinn (1972) describes math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations" (551). Williams seems to agree by describing it

as "an emotional and cognitive dread of mathematics" (96).

Janet R. Handler promotes a slightly different angle on the subject. She emphasizes the fear of having to demonstrate mathematics skill rather than the fear of mathematics itself. This could be translated into a fear of failure when attempting to show mathematical skill. Handler goes on to say that this fear feeds itself by creating more anxiety when failure is experienced (Handler, 21).

The notion that demonstration of math ability may be the leading factor in describing math anxiety has lead some researchers to believe math anxiety may be mistaken for test anxiety in some cases. Test anxiety is described as a fear of an evaluative situation.

Test anxiety may be divided into two more components: 1) Worry and 2) Emotionality. Worry is the cognitive aspect of test anxiety which causes the student to repeatedly tell him/herself that they will perform badly or even that they are too "stupid" to do well on a test. This extraneous mental activity can interfere with organized thought processes and prevent good analysis of test questions and timely recall of information needed to answer these questions. Emotionality is the side of test anxiety which entails physical symptoms such as feelings of nervousness and tension, perspiring, feeling faint, etc. (Wigfield, Meece, 210; Beck 161-163)

It must be noted that a definition of a math-anxious individual does not necessarily include "one who does poorly

in math." Factors such as perceived importance or value of math and perception of one's own ability (or lack of ability) to do math may contribute to anxiety while actual skill remains high.

Causes of Mathematics Anxiety

I think that researchers would agree that there is no one cause of math anxiety. Hence, there are many theories which attempt to explain its causes. As a prospective math teacher, I need to be aware of some of these theories in order to have some background when dealing with a math-anxious student. A few of these theories will be described here.

A) Relational vs. Instrumental Understanding/Teaching

Richard R. Skemp describes the difference between relational and instrumental understanding in his book, The Psychology of Learning Mathematics. Relational understanding is described by Skemp as, "the ability to deduce specific rules or procedures from more general mathematical relationships." (Skemp, 166) In other words, a student with this type of understanding knows what to do and why a particular method works. Instrumental understanding, on the other hand, is defined as "the ability to apply an appropriate remembered rule to the solution of a problem without knowing why the rule works" (Skemp, 166) or knowing what to do, but not why.

Problems may occur when a teacher is teaching relationally, but a student is only interested in instrumental understanding. For instance, this may become evident when the student is able to recall and work all of the formulas presented in a unit but cannot apply them to story problems using these formulas. A student without relational understanding of a unit may also have trouble using past information to reinforce new information.

In a situation of this type, a student may feel that the teacher is making concepts too "complicated." They just want to learn the "rule" and be finished. No amount of explaining seems to change his/her mind. What the student may not realize is that not all situations will necessarily fit a given "rule."

The opposite situation may also occur. In this case, the teacher may be teaching instrumentally while the student is struggling to understand concepts relationally. According to Skemp, this situation is even more damaging because without knowledge of why a certain rule or concept works, applying it to future situations becomes very difficult. For instance, phrases like "turn it upside down and multiply" when dividing fractions may cause trouble for the child who doesn't understand why this rule should work. It will not be as easy to apply this knowledge to complex fractions because the problems will look different and might not seem to fit the rule. Skemp also says many text books contribute to this problem as much or more than teachers.

(Skemp, 153)

Most classrooms contain both relational and instrumental learners and most teachers use both styles, depending on the concept being taught. Which is better? Although, ideally, it would seem that relational understanding should be the best, Skemp lists advantages for both. As advantages for instrumental understanding he lists the following:

1) Instrumental Mathematics is usually easier to understand.
2) The rewards are more immediate, and more apparent.
3) One can often get the right answer more quickly.

(Skemp, 158)

Advantages for relational understanding include:

1) It is more adaptable to new tasks.
2) It is easier to remember (but sometimes harder to learn).
3) Relational knowledge can be effective as a goal in itself.
4) Relational schemas are organic in quality.

(Skemp, 158)

In spite of the long-term advantages of relational understanding, many teachers end up teaching much of their material instrumentally. Why? Skemp listed several reasons:

1) Relational understanding takes too long to achieve and instrumental understanding of some concepts is

all that most of the students will ever need.

2) Relational understanding of a concept is too difficult but the students still need the material for standardized examinations.

3) A particular skill is needed for another class (a science course, for instance) before it can be relationally understood with their present backgrounds.

4) The teacher may be a junior teacher in a school where all other teachers teach instrumentally. (Go with the flow.) (Skemp, 160)

B) Attitudes of Elementary Teachers Towards Mathematics

Many researchers believe that a major factor in determining a student's tendency toward math anxiety may be the math attitudes of his/her elementary teachers. This theory focuses on the vicious cycle that could result from math-anxious elementary teachers creating math-anxious students who grow up to be math-anxious parents and teachers.

There are various ways that an elementary teacher may communicate a dislike for or an anxiousness about mathematics without even knowing it. For instance, research has shown that a math-anxious teacher might let other subjects or tasks encroach upon time scheduled for math activities with alarming frequency. A math anxious teacher will also tend to rely solely on the text's explanations and

examples (instrumental explanations) without much discussion of why answers are right or wrong (relational explanations). One more method of communicating math anxiety inadvertently may appear when a student challenges an answer unexpectedly. A math-anxious teacher might go immediately to the teacher's manual instead of working out the problem for the entire class to see. This may communicate an unsureness that the method/lesson being taught actually works. (Martinez, 120)

It must be pointed out that the research cited here does not necessarily indicate that elementary teachers are incompetent in their math abilities. Rather, they seem to be less confident in their math abilities than their abilities in other subjects and the students pick up on this.

A study conducted at the University of Minnesota in the 1980-1981 school year indicated a high level of math anxiety among pre-service elementary teachers relative to college students in other fields of study who might be considered "math avoiders." Math avoidance was considered by these researchers to be a good indication that a student was possibly math-anxious. Groups of math avoiders identified by and used in this study included freshmen with no college preparatory math courses, freshmen enrolled in college algebra (thus with little college preparatory math), and students participating in a workshop for math-anxious students at the university.

This study, which used Richardson and Suinn's Mathematics Anxiety Rating Scale (which will be discussed

later in this paper) as its measuring tool, also indicated that female pre-service elementary teachers indicated a higher math-anxious tendency than males. The researchers did point out, however, the fact that there is no support for the belief that women cannot do as well as men in math. Rather, they seem to show a higher level of anxiety when dealing with it. In interpreting the data, these researchers suggested that since anxiety seemed to be so high among female pre-service elementary teachers, perhaps it was the female elementary teachers who were instilling math-anxiety in the girls in their classrooms and perpetuating the vicious cycle in this way. (Kelly, Tomhave 51-53)

A substantial amount of research has been conducted which supports the theory that elementary teachers tend to be math-anxious or at least that students who choose to become elementary teachers tend to be those who don't enjoy mathematics. One author suggested this self-quiz to enable teachers to identify themselves as possibly math-anxious.

Teachers' Math Anxiety Self-Quiz

Answer each of the following questions *yes* or *no* by making an X in the appropriate column. Work quickly, giving your first spontaneous responses.

	YES	NO
1. Do you dislike working with numbers?	____	____
2. Do you dislike reading graphs or charts?	____	____
3. Have you ever had trouble with a math class?	____	____
4. Do you consider yourself to be a verbal rather than quantitative—a word person rather than a numbers person?	____	____
5. Would you rather give your students a lesson in history or art than an arithmetic lesson?	____	____
6. Would explaining fractions or decimals to a grade school class be difficult for you?	____	____
7. If you worked an arithmetic problem and got an answer different from the one in the book, would you assume the mistake was yours?	____	____
8. Do you perspire or does your heart beat increase when you take a math test?	____	____
9. Do you believe that people who are good at math were born with that ability?	____	____
10. Have you ever avoided taking a math class?	____	____

Add up the numbers of *yes* and *no* responses. If there are more *yes* than *no* responses, you may be math anxious. The greater the number of *yes* responses, the greater the chance of your being math anxious.

(Martinez, 119)

C) Parents' Attitudes Towards Mathematics

A third theory that will be discussed here suggests that children can acquire math anxiety from their parents. It has been suggested that there are two primary ways parents transfer math-anxiety to their children: 1) Role-modeling and 2) Interpreting their children's achievement outcomes. (Wigfield, 3)

The role-modeling theory may be compared to a "monkey-see, monkey-do" situation. In other words, if children see their parents performing math-related tasks with confidence, they are more likely to feel comfortable with math. The opposite is also true. For instance, if Sally sees Daddy get flustered every time he tries to balance the checkbook, she may see this as a task involving numbers which should be dreaded, or even feared.

By interpreting children's achievement outcomes, parents send signals, whether intentionally or not, to the children which influence what children expect from themselves. This is not to say that the children have the same expectations for themselves as their parents have for them (the children). Rather, the children may expect from themselves the same things that they <u>believe</u> their parents expect from them. (Wigfield, 6) Parents who believe that math is difficult for their children are found to have children with lower self-concepts in their abilities in math. This achievement interpretation factor seems to be more influential than the role-modelling as far as parental

influence on children is concerned.

Testing for Mathematics Anxiety

Almost as important as finding the causes of mathematics anxiety is finding ways to test for it. Early anxiety tests attempted to measure general anxiety. Soon it became apparent to researchers that there were various distinct types of anxiety, one of which seemed to be Number Anxiety. Researchers Ralph M. Dreger and Lewis R. Aiken Jr. conducted a study during the 1950's designed to test the following hypotheses: 1) Number anxiety could be defined as 'distinct' from general anxiety, 2) Number anxiety is not related to intelligence, and 3) An inverse correlation exists between one's number anxiety and one's scores in mathematics. (Dreger and Aiken, 345)

The Taylor Manifest Anxiety Scale, which measures several dimensions of anxiety, was modified by replacing three items which had relatively low validity with three items which were intended to detect number anxiety specifically. When the revised Taylor Scale was given to 704 basic mathematics students at Florida State University, the results yielded sufficient evidence to support all three of the given hypotheses.

Perhaps the most well-known test created to detect math anxiety is the Mathematics Anxiety Rating Scale, also called the MARS, developed in 1972 by Frank C Richardson and

Richard M. Suinn. This is a 98-item test which was intended to measure anxiety related to real-life and academic mathematical situations in college-age students. Richardson and Suinn indicated that their test could be used as a diagnostic tool, to help assess the effectiveness of various treatments for math anxiety, or to evaluate changes occurring in further research in the area of math anxiety. (Richardson and Suinn, 552) Subjects who take this exam are asked to rate the level of anxiety that each situation described would induce in them, from 1="Not at all" to 5="Very much." Therefore, high scores indicated high mathematics anxiety.

Since the MARS was developed, there have been several variations of it developed by other researchers. In 1982 Suinn and Ruth Edwards saw a need to modify the MARS so that it could be used to test adolescents. They felt that earlier detection of math anxiety in students could enable schools to provide more adequate counseling programs and special curriculum assignments in order to help students earlier in their math careers. The revisions were mostly in the form of changes in the wording of some items and the addition of some new items to make it more appropriate for adolescents. The same rating scale was used. Some examples of items on the MARS-A include: "Collecting money to buy tickets," "Playing cards where numbers are involved," "Deciding how much of a tip to leave," and "Doing a word problem in algebra." (Suinn and Edwards, 577) A MARS-E was

also developed for similar reasons in order to test elementary-aged children.

In analyzing the Mathematics Anxiety Rating Scale, Rounds and Hendel discovered that it actually measured two separate factors which could affect a student's response to mathematics. The first they termed Math Test Anxiety (A fear of having one's math skills tested) and the other, Numerical Anxiety (A fear of numbers in everyday situations) with the former being the more prominent factor being tested by the MARS. In other words, the MARS seems to <u>define</u> math anxiety as a fear of being tested over or having to display ability to do mathematics rather than the fear of actual numerical manipulation.

The multidimensionality of the MARS was not the only problem that was found with it. Researchers Livingston Alexander and Carl Martray focused on the length of the MARS in their attempt to revise it in 1989. They contended that a shorter test would be far more useful in the classroom and set out to devise a shortened version which would serve the same basic purpose (diagnose students with math anxiety) and also the additional purpose of identifying specific background variables which could serve as predictors of math anxiety. (Alexander and Martray, 144)

This additional purpose was explored by comparing the results of the shortened (now 69 items) MARS with results of another set of diagnostic tools, the Mother, Father, Teacher, and Mathematics Usefulness subscales of the

Fennema-Sherman Mathematics Attitude Scales. This set of scales was published in 1976 by Elizabeth Fennema and Julia A. Sherman in order to study attitudes toward mathematics and to explore some possible causes for these attitudes. The Mother, Father, and Teacher scales were designed to measure students' perceptions of the interest, confidence, and encouragement present in these significant people as related to the mathematical abilities of the student.

In addition to the subscales already mentioned, there were several others, such as the Attitude toward Success in Mathematics Scale which attempted to assess motives to avoid mathematics. The Mathematics as a Male Domain Scale, in the words of the authors, "is intended to measure the degree to which students see mathematics as a male, neutral, or female domain in the following ways: a)the relative ability of the sexes to perform in mathematics; b) the masculinity/femininity of those who achieve well in mathematics; and c) the appropriateness of this line of study for the two sexes." (Fennema and Sherman, 3) The Confidence in Learning Mathematics Scale measures one's confidence in his/her ability to learn and perform well in mathematics. The Effectance Motivation Scale in Mathematics attempts to measure one's willingness to involve oneself in mathematical activities. Finally, there is even a Mathematics Anxiety Scale whose purpose should be fairly obvious.

Eighteen to twenty-two items were selected for each

scale with about half being stated positively and half stated negatively. The items were then distributed randomly to create one test and the different scales are analyzed separately upon scoring of this test. Students are asked to respond to the items with a five-point scale that ranged from strongly agree to strongly disagree.

Why Is Math Anxiety Important to Understand?

As I have attempted to explain in this paper, math anxiety is a rather abstract concept with many definitions, but it is very real to those who suffer from it. Estimates for the percent of students who experience math anxiety range from 11% to 68%. This figure would be very difficult to pinpoint, but it is still important that teachers be able to detect math anxiety so that they can help alleviate it. Teachers need to understand how students feel about math and why they have these feelings in order to communicate with them in the most productive possible ways.

Discussion

While researching this topic, I spoke informally to several people that have, in the past, expressed a fear of math and asked them to tell me about the origins of their math anxiety. When I asked one college student "When was the first time you remember having bad feelings toward math?" he responded with an interesting story. He said that he could remember being placed in the "low" math group in 1st grade and feeling bad about that. He remembered feeling

jealous when he overheard his teacher giving the "high" group what he perceived to be shortcuts to doing their work while he was forced to plod through at a beginner's level.

From this story I might hypothesize that this student's anxiety might have been related to his perception of his teacher's views about his math ability. He felt that the teacher put him in the lower group because he "wasn't any good at math." There may also have been a problem with teaching and learning styles. His teacher, recognizing that he did not have a relational understanding of some of the concepts being taught, may have put him in the slower group in order to give him more time to learn them better. At the same time the children in the higher group may have had a better relational understanding and were ready to learn instrumental concepts that would help them in their homework.

Another story that I found interesting came from a grade school classmate of mine. In second grade, we were given timed tests every week to help polish our addition, subtraction, multiplication, and division skills. We had one minute to complete as many problems as we could from a given worksheet. If we completed a certain number of problems correctly, we got to be "Math Minute Men" and were given a sticker to place next to our names. I remember doing this and thinking that it was a fun sort of challenge. On the other hand, one of my classmates told me that she used to get very upset and her mind would "freeze."

Therefore, she rarely finished enough problems to earn the rewards.

This may sound trivial, but to a second grader it is extremely important. Her math self-concept was affected by the fact that she never seemed to do well enough to earn a reward. At a slower pace, she had a good relational understanding of addition, subtraction, multiplication and division and could do the problems accurately. These tests were evaluating her instrumental abilities which hadn't developed to a level that would enable her to pass them. I'm not sure that these tests were completely negative because, for students who were good at them, they provided a confidence boost. Perhaps it would have been better if they weren't emphasized quite as much so as not to harm the confidence levels of those who struggled with them.

One of the college students that I tutor related a different story about his math experiences. He claimed that he had little trouble with math throughout elementary school and junior high. His problems began in algebra during high school. After asking him more about this I realized that his difficulty was related to the concept of a variable. He had had trouble understanding how variables worked and that put him behind for the rest of his math career.

This incident occurred because this student could not grasp a relational understanding of a variable and therefore could not perform instrumental tasks dealing with the variable. In other words, although he was handling tasks

that required concrete operational thinking with adequate skill, he was not ready to understand concepts that required formal operational thought processes. Perhaps if he had waited a year or so to take algebra, or had taken it again the next year, he would be less anxious about math today.

I find it interesting that most of the people I have spoken with can relate their math anxieties back to one or two specific incidences that seemed to define their feelings about math from then on. Perhaps this would support the conclusion that math anxious people are "made" math anxious by things that happen around them. How can we help these people overcome this anxiety?

I have one theory that I hope to pursue in my career as a math teacher. It is my personal belief that if we focus more time on teaching students to <u>read and write about</u> math at an earlier age, they will have fewer problems later on. If a student is able to read his or her math book, they will have access to relational and instrumental information which can help them to find what they need when they need it. In response to this, some will say, "They already have books and this doesn't seem to help." It is true that they have the books but they aren't being taught to read them. I can't count the number of people who have come to me for help with math homework and tell me that it's useless to read the sections in the book because they can't understand what's written there anyway.

I'll admit, reading a math book can be difficult (and,

yes, even boring)! Like most things, this is an acquired skill that can only be obtained through practice. Too many teachers spell out everything during class time and don't require the students to read their books at all. Students need to practice reading the sections of their math books and perhaps rewriting concepts in their own words. It may help to read the sections aloud in partners or even during class time, stopping every few sentences to review and clarify.

Someday I would like to test this theory by working with elementary teachers to develop programs that would teach younger students to read mathematics more successfully. However, as a beginner in this field, I have a lot to learn from those who have been studying the problems of math anxiety in our students; and I look foreward to learning it.

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