Math Anxiety and Elementary Teachers: What Does Research Tell Us?

ERIC F. WOOD

It is now ten years since Sheila Tobias published her book, *Overcoming Math Anxiety*. At the time of the book's release, the phrase "math anxiety" had been taken up as a battle cry by the media as the reason and rationale for many of the problems that mathematics educators faced. So pervasive was the media attention, that math anxiety became one of the few mathematics education issues to appear as the focus of certain popular cartoon strips [see, for example, Larson, 1986]. In spite of the fact that the popular press no longer appears to consider this issue a newsworthy one, the educational community is still very much interested in the topic. It is precisely because the issue of mathematics anxiety is no longer clouded by the media attention previously given to it that an analytical look at what ten years of research on the subject has been able to find out is now possible.

The main goal of this paper is to try to synthesize what the research literature tells us about the importance of mathematics anxiety to elementary teachers at both the preservice and the inservice levels. It is not possible, however, to restrict the discussion to this focus alone because the whole field of mathematics anxiety has other dimensions that affect how the research must be interpreted. Consequently, the paper will consider five general areas of importance:

1. A general overview of the problem of mathematics anxiety, its definition, and the techniques that are used to measure it;
2. A brief discussion of some of the gender related issues;
3. An analysis of the research dealing with the effect of mathematics anxiety on elementary teachers and their teaching performance;
4. A brief look at some intervention strategies and treatments aimed at reducing mathematics anxiety; and
5. Conclusions and implications for future research efforts.

Within the context of each of these five general areas, I will attempt to frame and then answer certain specific questions that I feel to be important to an overall understanding of the topic, and to the development of a conceptual framework for the ideas considered in the paper.

Definition of the problem

A number of interesting and important questions arise out of any attempt to define or measure mathematics anxiety: What exactly is mathematics anxiety? Does it really exist separately from other kinds of anxiety? Is it a useful psychological construct? How accurate and/or reliable are the tools that are used to measure mathematics anxiety? None of these questions can be simply and unambiguously answered; however, any discussion should start with as clear a definition of the terms under scrutiny as possible.

Different writers give varying amounts of emphasis to certain of the components that appear in most definitions of mathematics anxiety. Some scholars do not in any way link their definition to school mathematics but rather use the term math anxiety to "describe the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem" [Hunt, 1985, p. 32]. The words used here are very strong ones and serve to emphasize the belief that the emotions that dealing with mathematics can evoke can be so powerful that people will go to extreme lengths to avoid any encounter with mathematics at all. For example, "[One] teacher in an adult group workshop reported that calculating the tip in a taxi was often so distressing that she preferred to walk, carrying heavy suitcases rather than experience such discomfort" [Donady and Tobias, 1977, p. 71].

Although many other writers share the view that mathematics anxiety is a very intense and debilitating phenomenon [Sherard, 1981], it is not always presented in quite such emotionally charged terms. Earlier researchers in this field give a somewhat more pragmatic definition of mathematics anxiety. In their view mathematics anxiety "involves feelings of tension and anxiety *that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations*" [Richardson and Suinn, 1972, p. 551, cited in Reyes, 1984, p. 565, emphasis added]. This definition tends to focus on the actual effect of mathematics anxiety on mathematical performance rather than on the emotional impact that it may have on the individual. Furthermore, it avoids the troublesome tendency on the part of many of the writers in this field to equate math anxiety and math avoidance. It is clear from the literature that although these two concepts may be related they are, in fact, very distinct from each other.

A further complication of the problem of finding a suitable definition for mathematics anxiety arises because some researchers do not specifically use the term at all but rather talk about anxiety that is experienced while doing mathematics [Fennema, 1979]. It becomes a subtle but important

question to decide whether mathematics anxiety describes, or is a function of, some peculiar feature of the discipline of mathematics itself that produces a specific kind of anxiety that interferes with people's ability to perform mathematical tasks, or rather, whether doing mathematics produces anxiety of a more general nature

If the second view is accepted then the focus should be on the societal, educational or environmental factors that lead an individual to perceive mathematics in an anxiety producing fashion. If, on the other hand, the former view is accepted, the emphasis will center on the intrinsic features of mathematics that cause it to produce such feelings I would suggest that there is a significant difference between a condition that causes a person to avoid at all costs the small amount of mathematics required to check a bill in a restaurant and a condition that causes someone to become concerned when they cannot get a particularly difficult problem on a college level mathematics examination Unfortunately, the uneasiness felt in situations even as diverse as these is often claimed to be a result of mathematics anxiety

This discussion of the way that the term mathematics anxiety is used is, in my view, an important indicator of some of the problems that arise when dealing with this notion. The ambiguity and lack of consistency with which people use the expression further exacerbate the difficulty of deciding how to measure it or what it is that is actually to be measured In spite of the difficulty of definition, a number of psychometric methods have been developed that purport to measure mathematics anxiety (at least as defined or understood by the person designing the instrument) A number of significant facts arise out of a study of some of the scales that have been developed to assess mathematics anxiety, facts that will illuminate the earlier questions about the definition and existence of a construct that could justifiably be called math anxiety

Measurement of math anxiety

Although research on the measurement of what was denoted "number anxiety" was done in the mid 1950's [Dreger & Aiken, 1957] the first comprehensive scale designed specifically to measure math anxiety was developed by Richardson and Suinn [1972] The Mathematics Anxiety Rating Scale (MARS) consists of a total of 98 items and the respondents are required to answer various questions dealing with situations in which mathematics is prevalent. Based on their responses on this Likert-type scale, a score that is claimed to reflect the degree to which that particular individual is affected by mathematics anxiety is produced. A variety of other tests have also been devised [Fennema and Sherman, 1976; Sandman, 1980], however, psychometric data on the reliability and validity of these scales is not so widely available as it is for the MARS. Consequently, much of the discussion that follows will be related to the MARS because of its wide use in the research.

A crucial question that can be asked about any scale that is designed to measure attitudes or other difficult to define quantities is: What does it really measure? In attempting to answer this question, psychologists have cast a significant amount of light on the previous questions that were discussed with relation to the definition of mathematics anxiety. Rounds and Hendel [1980] attempted to establish the dimensionality of mathematics anxiety They administered the MARS to a population of 350 college females and then performed a variety of statistical procedures on the data A factor analysis of the responses led them to conclude that there are in fact two dimensions that are measured by this scale. One factor that referred to anxiety caused by the actual doing of mathematics they named Numerical Anxiety, while another factor that contained items referring to writing mathematics tests or taking mathematics courses they termed Mathematics Test Anxiety. Furthermore, a correlation between the subscale derived from those items that claimed to measure Mathematics Test Anxiety and overall test anxiety (using the Suinn Test Anxiety Behavior Scale) showed a strong positive correlation ($r = 0.75$).

Further analysis led the authors to conclude that the participants in this study exhibited almost no anxiety with respect to the component identified as the Numerical Anxiety measure but did demonstrate a fair amount of anxiety on the Mathematics Test Anxiety portion of the scale. They concluded further that

> the domain of mathematics anxiety as measured by the MARS is best described *not* as anxiety about everyday numerical manipulation, but primarily as test anxiety and secondarily as anxiety associated with mathematics courses. The most salient items for Factor 1 (Mathematics Test Anxiety) involved anticipation, completion and receiving the results of mathematics tests [Rounds and Hendel, 1980, p. 145]

Other studies [Alexander and Cobb, 1984; Plake and Parker, 1982; Brush, 1981] also examined the MARS and found that whatever it measured was also a two dimensional construct. In every case, although the actual terms that were used to describe the two constructs varied, the notions of numerical functioning and mathematics evaluation were identified Although one recent study claims that mathematics anxiety is unidimensional [Frary and Ling, 1983] the conclusion is rendered less compelling by the fact that the study was designed essentially to measure the attitude of the subjects to mathematics rather than specifically to investigate mathematics anxiety.

Finally, a study that measured the physiological arousal state of subjects while doing mathematical tasks and writing mathematics tests as measured by heart rate, galvanic skin and response and so on, found that "the math anxiety measures showed little relation to physiological measures and to avoidance behavior" [Galassi and Dew, 1984b, p. 582] Such evidence casts some doubt at least on any kind of instrument that asks people to judge their own feelings of anxiety because the claim to be math anxious does not appear to match the physiology associated with anxiety This study is also interesting in the fact that it measures similar kinds of physiological factors as the earlier study by Dreger and Aiken [1957]. Although these researchers

found that the galvanic skin response *did* undergo significant changes, these changes were only significant when persons that were considered to be number anxious were given an arithmetic task to do *and* informed that the purpose of the study was to see how good they were at arithmetic.

All of the studies quoted in the preceding paragraphs refer to studies done by psychologists, not mathematics educators, and consequently, they do not make any attempt to interpret the results of the experiments in the context of learning or teaching mathematics. It seems clear, however, that there is a significant amount of doubt about whether mathematics anxiety as a separate construct does indeed exist. The evidence derived from the factor analytic studies clearly illustrates the fact that test anxiety is measured much more often by the MARS than anxiety associated with *doing* mathematics; furthermore, even the physiological studies show little relationship between stated anxiety about doing mathematical tasks and actual anxiety *except when the subjects were told (or they inferred that) they were being evaluated*. Even if it is assumed that a construct called mathematics anxiety does exist, the evidence suggests that the measurement of such a construct is far from precise. In fact, there is no strong positive correlation between the MARS, Fennema and Sherman's Mathematics Anxiety Scale and Sandman's Anxiety Towards Mathematics Scale [Dew and Galassi, 1983a].

The implications of this research are troublesome: If mathematics anxiety is not a construct separate and distinct from test anxiety, how can it be treated in a framework that does not include a component to address apprehensions about tests? Can people who are naturally disposed to be anxious ever be "cured" of such a condition? I am not suggesting that nobody has an irrational fear of mathematics; certainly people have phobias about all sorts of things. However, to suggest that such a feeling is the norm for all people who get a high score on the MARS test, or some other comparable instrument, is misrepresenting the facts

Gender-related issues

It is because of these uncertainties about mathematics anxiety and its measurement that much of the rhetoric about its role in the math avoidance behavior of females is particularly misleading. For example, when we see it suggested that the explanation of the fact that only 8% of the female first year class at Berkeley in 1972 had the prerequisities for any college level calculus or statistics course is that females exhibit a high degree of mathematics anxiety and consequently avoid mathematics, one has to wonder if, in fact, this is an adequate explanation of what is really going on [Betz, 1977]. Such contentions about women having high levels of math anxiety also need to be evaluated in the light of other information.

In a sampling of 1045 freshman, it was found that most students exhibited very low levels of mathematics anxiety and that there were no significant differences due to gender in either the sample as a whole or within the different courses in which these students were enrolled [Resnick, Viehe and Segal, 1982]. A study done by Butler and Austin-Martin [1981] attempted to find what first year female math anxious students had in common. After the project was finished all that they could conclude was that "... math anxiety appears to be a construct that is not easily definable and that varies sufficiently with each individual that a set of common characteristics of high math anxious college freshmen women does not exist" [p. 7]. Coupled with these results is the fact that females are typically more ready to admit that they are anxious about things in general [Reyes, 1984]. Evidence such as this makes it more and more difficult to accept as fact some of the "conventional wisdom" about mathematics anxiety being a female domain.

The truly unfortunate part of this linking of female math avoidance with mathematics anxiety is that the entire issue has become inextricably linked with the women's movement and equated with issues of equity of educational experience. The amount of rigorous examination of the entire problem in the early stages of discussion when "mathematics anxiety" became the root of all problems with mathematics education was very small. As is often the case in society, the easy answer took precedence over the correct one, and people found it convenient to be able to blame the actual differences in women's mathematical behavior on anxiety. Such a position also allowed researchers a rationale for not attempting to look for some of the other, more complex, societal reasons behind the math avoidance of females. It is only now that researchers are pursuing this issue with something resembling a scientific method, and the results, as we have seen, are certainly not as clear cut and simplistic as many of the earlier positions taken by those who popularized the issue.

To summarize this general introduction to the issue of mathematics anxiety, it can be stated that:

1. Mathematics anxiety does not appear to be caused by the doing of mathematics but does appear to be strongly related to test anxiety
2. It is not clear that the measurement of mathematics anxiety by pencil and paper tests accurately matches the body's actual physiological responses to doing mathematics
3. Reports that women are more susceptible to the effects of mathematics anxiety are inconclusive and tenuous at best
4. The true extent of the problem is very difficult to ascertain because of conflicting results in the experimental literature.
5. The science of testing for mathematics anxiety is an imprecise one that still needs much refinement before confidence can be placed in the results

Mathematics anxiety and elementary teachers

After the discussion in the previous section about the inconclusive nature of the research on mathematics anxiety one might be tempted to wonder why it is necessary to proceed with the discussion about elementary teachers and how they are affected by mathematics anxiety. After all, why talk about a construct if it does not exist? Such a view

would be simplistic, however, because regardless of whether mathematics anxiety is a useful construct in and of itself, or even if it is a reflection of some other deep-seated attitudes towards mathematics, people do have negative views about mathematics that are often reflected in feelings of uneasiness when they are required to operate mathematically. Furthermore, one could argue that when teaching mathematics the teacher is *constantly being evaluated,* and this evaluative situation does lead to anxiety, especially in those individuals who are flagged as math anxious by the various scales.

There is good reason to believe, therefore, that in spite of the inadequacies of the definition and measurement of mathematics anxiety, teachers who are rated as mathematics anxious by the scales that are presently in use probably do harbour significant and potentially detrimental feelings towards mathematics, whatever the label we apply to those feelings. For the purposes of the following discussion I will use the term math anxiety as a way of talking about the general lack of comfort that someone might experience when required to perform mathematically, and the ramifications of such a disposition in an elementary teacher. Once again a number of important questions are raised by this idea: Are elementary teachers as a group anxious about mathematics? Does this attitude affect their teaching methods and classroom performance? How are the student's attitudes towards mathematics shaped by the teacher's feelings?

The research on the scope of the problem of math anxiety in the elementary teaching population is very contradictory. If we are to judge by the number of articles in the popular educational literature that deal with the problems of elementary teachers who are required to teach mathematics even though they are afraid or anxious about the subject, we would conclude that the problem is a large and significant one [Pearson, 1980; Burton, 1979; Kelly and Tomhave, 1985] However, many of the articles that one finds are based on the same studies and hence come to the same conclusions. The actual nature of the problem is much less clear.

Kelly and Tomhave [1985] tested a large group of college freshmen, including education majors, using the MARS. They found that the "elementary education majors scored higher (230.0) on the MARS than any of the other group except those in the math anxious workshop (321.6)" [p. 52]. They go further to conclude that "if the results of our study are representative of preservice teacher education, then women elementary school teachers, who constitute the majority of elementary school teachers, may be perpetuating math anxiety with young girls in their own classrooms" [p. 52].

Leaving aside the lack of conclusive evidence for the assertion that math anxiety is passed on by teachers to students, one could examine how representative these findings seem to be. Unfortunately, other studies of a similar nature give us a completely different picture. Becker [1986] used the Fennema-Sherman Mathematics Attitude Scales to investigate the general attitudes to mathematics of a group of college students, approximately half of whom were education majors. She concluded that "it seems inappropriate to classify this sample of prospective elementary school teachers as having an alarming degree of mathematics anxiety" [p. 51]. A study with experienced elementary teachers showed that only 16% would be classified as math anxious [Widmer and Chavez, 1982] and that although there were some differences between women and men these differences were not statistically significant [Chavez and Widmer, 1982].

An interesting follow up to the latter study was to select a subsample of twenty teachers and conduct in-depth interviews with the respondents. The teachers who were anxious about mathematics, or alternatively had negative feelings about mathematics, could clearly link such feelings or attitudes to an idiosyncratic, negative experience with a particular teacher in their own school careers. These findings confirm similar results for pre-service elementary teachers [Chapline, 1980a]. Typically these anecdotes involved an elementary teacher who embarrassed a student for not being able to compute accurately, often while at the blackboard. As difficult as it is to believe, some students actually claimed to have been called stupid in public by the teacher for being unable to do long division! It is hardly surprising that such behavior on the part of insensitive teachers would cause the development of poor attitudes towards mathematics (or any other subject for that matter). It is also interesting to note that many of these teachers took special pains to ensure that their students did not become math anxious.

It is a matter of judgement as to whether the level of mathematics anxiety in the population of elementary school teachers of mathematics is higher or lower than in the population at large; however, in some sense this is not the issue. If the scores on the MARS or some other scale are approximately the same for elementary teachers as for the general public, but these levels indicate an overall fear of or distaste for mathematics, then there is still a problem. Elementary teachers are charged with an extremely important role and that role is to engender an excitement for learning in all subject areas, including mathematics. It is also true that

> [They] cannot be expected to generate enthusiasm and excitement for a subject for which they have fear and anxiety. If the cycle of mathophobia is to be broken, it must be broken in the teacher education institution. The fears of both male and female teachers need attention. [Mihalko, 1978, p. 36]

Such a perspective implies that elementary teachers should have an attitude towards mathematics that is better than the attitude of the public at large and that they should feel more comfortable teaching mathematics than members of the general population would. Depsite the fact that the research does not support the hypothesis that most elementary teachers hate or fear mathematics, it does support the contention that a *significant minority* feels this way. What then can be done to improve this state of affairs? In the section that follows a number of intervention strategies are discussed along with the results that were achieved.

Interventions

Given the amount of attention that this issue received in the late 70's it is hardly surprising that a large number of research projects were set up to investigate ways of alleviating the perceived problems of mathematics anxiety, particularly in females Some of these projects were carried out as special programs separate from the regular teacher training course [Troutman, 1978; Chapline, 1984] while others were conducted in the context of the teacher education program itself [Sovchik, Meconi and Steiner, 1981; Battista, 1986]. In spite of the fact that methodological flaws can be found in the research design of some of them [Tittle, 1981], the evidence that these special programs did, in fact, improve attitudes towards mathematics and lower mathematics anxiety ratings as measured by a variety of scales is very convincing

What was it about these interventions that made such a big difference? In short the difference was that the students were well taught In all of the programs referred to, special care was taken to introduce material slowly, not to assume prior knowledge, to encourage the students to talk aloud about their thought processes, and so on. It may seem simplistic to say that such programs are simply using good teaching techniques but the reality is that this is precisely the case

An interesting bit of support for this conjecture comes from a study done by Singer [1986] where she looked at the change in mathematics anxiety levels of teachers who were enrolled in several different computer courses. In the course where BASIC was studied, the level of mathematics anxiety actually increased as a result of taking the course while the classes who studied LOGO and PILOT showed no such increase. It is easy to conclude that the kind of numerical work required in the BASIC course; the knowledge presumed by the instructor; and "the presence of people in the class who overtly perform some [mathematical tasks] with ease convinces those who are having difficulty that it is useless to try" [p 43]. Certainly this kind of class feeling was precisely the kind of atmosphere that these intervention programs were designed to avoid and, it appears, for good reason!

The truth of this interpretation is nicely emphasized in the words of one participant in a special anxiety-reducing program. In her journal she wrote:

> I'm beginning to believe that if I had had understanding teachers, *as I do now,* honestly, then I would have no trouble with math as I do now I am beginning to believe that I have the ability to learn and understand math, *if it is taught to me with understanding and skill.* I'm not saying that I can learn very advanced math over night, but I think that I wouldn't be as frightened to try [Chapline, 1980b, emphasis added]

It should be stated that this particular project consisted of people who were self-selected. That is, participants realized that they had a problem with the way that they thought about mathematics and as prospective elementary teachers they felt that they ought to try to do something about it. How far such results can be generalized to other groups is a little uncertain; however, in the other studies reported above, all of which had significant positive results in reducing mathematics anxiety, the participants were simply random classes of preservice teachers.

In a different approach entirely, another group of researchers tried to help students to learn to manage the anxiety they felt about having to teach mathematics by having them learn to practice deep muscle-relaxation therapy [Olsen and Gillingham, 1980]. The therapy did, in fact, work in the sense that it did lower the levels of perceived anxiety among the clients. This intervention, however, did not change the *attitudes* of the preservice teachers towards mathematics at all. Those interventions that tried to help relieve the anxiety levels of preservice teachers by changing the way that the students perceived and learned mathematics also had a significant effect on the attitudes of the students, even though this was not the primary function of the programs In this sense they could be judged to be more successful than those projects that simply taught stress management techniques

Summary an conclusions

Mathematics anxiety is a complex and elusive quantity that is difficult to define and even more difficult to measure. It is unclear whether it is possible to separate the ideas of general anxiety, mathematics anxiety and test anxiety in a meaningful way. Furthermore, the relationship of stated anxiety and attitude towards mathematics needs to be explored in much more detail in order that strategies to improve how people react to mathematics will provide a cure for the disease rather than a cure for the symptoms

A number of the questions that were posed as this discussion was developed remain unanswered Each of these provides a basis for further research endeavors in this area. For example, what is the interaction between teacher mathematics anxiety and student mathematics anxiety? I was unable to find this question addressed in any of the research studies that I read although a number of researchers said that it would be an important question to study.

Is there a relationship between mathematics anxiety and the way that teachers teach? Claims that math anxious teachers are rule-bound and rote-oriented are commonplace; but are such assertions, although plausible, necessarily true? I wonder if the knowledge base that elementary teachers bring to their teaching duties does not have even more of an impact than their claim to be math anxious. As a mathematics educator, I am more concerned by the fact that many beginning education students do not believe that elementary mathematics teachers have any need to know very much mathematics beyond the basic calculations than I am by the fact that some small percentage of these education students also claim to be math anxious [Bulmahn, 1982]

Clearly the study of human behavior, experience and emotion is a difficult and elusive process When one tries to link a construct called mathematics anxiety, which has so many other facets, to problems in mathematics education it is important to realize that although mathematics anx-

iety may be one reason for the less than ideal way that mathematics is often taught it must not be assumed to have more impact than presently available facts dictate Research must continue to attempt to illuminate all possible avenues of helping children to learn mathematics, including the development of positive attitudes in teachers. It would be foolish to assume, however, that positive attitudes without a solid knowledge base will do the job; rather, teachers must be knowledgeable *and* enthusiastic about the subject that they are teaching. It is the development of teacher preparation programs that will produce this kind of teacher that must be informed by research efforts in mathematics education

References

Alexander, L. and Cobb. R [1984, November] Identification of the dimensions and predictors of math anxiety among college students. Paper presented at the meeting of the Mid-South Educational Research Association. New Orleans, LA

Battista, M J [1986] The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers *School Science and Mathematics* 86(1): 10-19

Becker, J. R [1986] Mathematics attitudes of elementary education majors *Arithmetic Teacher* 33(5): 50-51

Betz, N. E [1977, August] Math anxiety: what is it? Paper presented at the Annual Convention of the American Psyhological Association San Francisco, CA

Brush. L R [1981] Some thoughts for teachers on mathematics anxiety *Arithmetic Teacher*. 29(4): 37-39

Bulmahn, B. J. [1982] On the transmission of mathematics anxiety *Arithmetic Teacher*, 30(3): 55-56

Burton. G [1979] Getting comfortable with mathematics *The Elementary School Journal*. 79(3): 129-135

Butler, M and Austin-Martin, G [1981, August] High math anxious female college freshmen: what do they have in common? Paper presented at the Annual Convention of the American Psychological Association Los Angeles, CA

Chapline, E. B [1980a April] TEAM: program development and evaluation. Paper presented at the meeting of the American Educational Research Association, Boston. MA

Chapline, E B. [1980b] *TEAM. final report 1979-1980* Washington, DC: Women s Educational Equity Action Program (ERIC Document Reproduction Service No ED 220 286)

Chapline. E B. and Newman, C. M [1984] *Demystifying math* Newton: MA Women's Educational Equity Action Program. (ERIC Document Reproduction Service No. ED 259 919)

Chavez, A and Widmer, C C. [1982] Math anxiety: elementary teachers speak for themselves *Educational Leadership* 39: 387-388

Dew K M. and Galassi, J P. [1983a] Mathematics anxiety: some basic issues. *Journal of Counselling Psychology* 30(3): 443-446

Dew, K. M , Galassi J. P and Galassi, M D [1983b] Math anxiety: relation with situational test anxiety, performance, physiological arousal, and math avoidance behavior. *Journal of Counselling Psychology* 31(4): 580-583

Donady B. and Tobias, S [1977] Math anxiety *Teacher* 95(3): 71-74

Dreger, R M and Aiken, L. R [1957] The identification of number anxiety in a college population *Journal of Educational Psychology*. 48: 344-351

Fennema, E. and Sherman J. [1976] Fennema-Sherman Mathematics Attitude Scales *JSAS Catalogue of Selected Documents in Psychology* 6:31

Fennema, E [1979] Women and girls in mathematics: equity in mathematics education *Educational Studies in Mathematics* 10:389-401

Frary. R B. and Ling. J L [1983] A factor analytic study of mathematics anxiety *Educational and Psychological Measurement* 43: 985-993

Hunt, G E. [1985] Math anxiety — where do we go from here? *Focus on Learning Problems in Mathematics* 7(2): 29-40

Kelly. W P and Tomhave, W K [1985] A study of math anxiety/math avoidance in preservice elementary teachers *Arithmetic Teacher* 32(5): 51-52

Larson, G [1986] *The far side*. New York: Andres, McHeel and Parker

Mihalko, J. C. [1978] The answers to the prophets of doom: mathematics teacher education In D B Aichele (ed.), *Mathematics teacher education critical issues and trends* Washington DC: National Education Association

Olsen, A. T and Gillingham, D E [1980] Systematic desensitization of mathematics anxiety among preservice elementary teachers *Alberta Journal of Educational Research*, 26(2): 120-127

Pearson. C [1980] New hope for the math-fearing teacher *Learning* 8(5): 34-36

Plake, B. S. and Parker, C S. [1982] The development and validation of a revised version of the MARS *Educational and Psychological Measurement* 42: 551-557

Resnick. H. Viehe, J. and Segal S. [1982] Is mathematics anxiety a local phenomenon? A study of prevalence and dimensionality *Journal of Counselling Psychology* 29: 39-47

Reyes, L H [1984] Affective variables and mathematics education *The Elementary School Journal* 84(5): 558-581

Richardson, F C and Suinn R M [1972] The mathematics anxiety rating scale: psychometric data *Journal of Counseling Psychology* 19:551-554

Rounds, J B. and Hendel. D D. [1980] Measurement and dimensionality of mathematics and anxiety *Journal of Counseling Psychology* 27(2): 138-149

Sandman, R S [1980] The mathematics attitude inventory: instrument and user s manual *Journal for Research in Mathematics Education* 11(2): 148-149

Sherard, W. H [1981] Math anxiety in the classroom *The Clearinghouse*, 55:106-110

Singer, B J [1986] An investigative study of possible effects of programming instruction on math anxiety and attitudes toward CAI *Journal of Computers in Mathematics and Science Teaching* 5(4): 40-43

Sovchik, R , Meconi, L J and Steiner, E [1981] Mathematics anxiety of preservice elementary mathematics methods students. *School Science and Mathematics*, 81:643-648

Tittle, C K. and Denker, E. R [1981. April] Issues in the outcome evaluation of a mathematics anxiety reduction program for teacher education students Paper presented at the meeting of the American Education Research Association Los Angeles, CA

Troutman. J G [1978. April] *The effects of a mathematics clinic in reducing anxiety in female students* (ERIC Document Reproduction Service No ED 156 538)

Widmer, C. C. and Chavez, A. [1982] Math anxiety and elementary school teachers *Education* 102(3): 272-276