Math Anxiety Explorations: A Critique of Two Studies

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What follows is a critique of two research studies on math anxiety. The first study is "Math anxiety in elementary and secondary school students" by Wigfield and Meece. The second study is "The effects of feedback treatment on math-anxiety levels of sixth grade Turkish students" by Aksu and Saygi. I have described each study as reported by the researchers and then critiqued each one. Finally I have compared and contrasted the two studies.

Description of study 1

Wigfield and Meece open their report by pointing out the work that has already been done concerning math anxiety. First, they indicate that math anxiety has negative effects on students' achievement and performance in mathematics. Certain features of mathematics such as precision, logic, and emphasis on problem solving, make it particularly anxiety provoking for some individuals. Second, they point out that research has shown that math anxiety contributes to differences in mathematics achievement and course enrollment patterns between sexes.

Wigfield and Meece then isolate areas concerning math anxiety that have received less research attention. The first area being the dimensionality of math anxiety characterized by worry, which is a cognitive component of anxiety, and emotionality, which is an affective component of anxiety. Wigfield and Meece indicate that most available measures of math anxiety focus on affective reactions to mathematics. An example is a 98-item Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn in 1972 and it is the most frequently used measure of math anxiety. Researchers assessing the dimensionality of MARS and its counterpart for use with adolescent, MARS-A, found that MARS is primarily a measure of negative affective reactions to mathematics. The second area of math anxiety that has received less research attention is the distinctiveness of math anxiety as a psychological construct. Research has found that math anxiety and mathematics ability concepts are highly inversely correlated. Wigfield and Meece suggest that more work is needed in order to find out whether these constructs can be distinguished more clearly or not. The third area is that most studies on math anxiety have been conducted with high school and college-age students, so that very little is known about its prevalence among younger pupils. Available information shows that math anxiety scores of younger students, like test anxiety scores, increase across age but there are doubts as to whether there are gender differences in math anxiety among younger students.

Wigfield and Meece established the rationale for conducting the study by assessing three issues. First, they assessed the dimensionality of math anxiety. They assessed whether cognitive and affective components of math anxiety could be identified in children in grades 6 through 12. Second, they assessed the distinctiveness of math anxiety as a psychological construct. They assessed relations between math anxiety and key attitudes, beliefs, and values related to mathematics, as well as performance in mathematics. Third, they assessed age and gender differences in math anxiety. On the basis of previous findings Wigfield and Meece hypothesized that math anxiety increases with age. They also hypothesized that girls were expected to express more math anxiety than boys, especially in the upper grades.

The study was done over a period of two years. In Year 1 Wigfield and Meece selected a sample of 740, predominantly white, middle-class students in the 5th through 12th grades. In Year 2 the sample consisted of 564 children (298 boys and 266 girls) in Grades 6 to 12. The children completed the Mathematics Anxiety Questionnaire (MAQ). The intermediate sampling unit of the study was the mathematics classroom. These classrooms, at each grade level, were chosen randomly from among the classrooms whose teachers volunteered to participate in the study. The MAQ was given only during Year 2 and so in the data analysis reported in this study, Wigfield and Meece used primarily Year 2 data.

Wigfield and Meece made use of two instruments: the MAQ and Student Attitude Questionnaire (SAQ). The MAQ was designed to measure possible cognitive and affective components of math anxiety. This instrument was developed in several steps. First, Meece in 1981 defined six possible dimensions of anxious or negative reactions to mathematics for assessment: dislike, lack of confidence, discomfort, worry, fear, and confusion/frustration. Meece then created items to assess each of these dimensions and put them into an instrument. After a pilot trial of the instrument, 22 items were incorporated into a battery of measures. The MAQ used in Wigfield and Meece's study contained items that in Meece's study had adequate variability and loaded highly on factors derived by Meece in 1981. An additional item con-

cerning students' dread of mathematics was added to the scale, as was an item concerning how much time children would like to spend on mathematics in school.

The SAQ was designed to assess students' expectancies of success and the incentive value of perceived ability, perceived effort, and perceived task difficulty. This 11-item questionnaire focuses on negative affective reactions to doing mathematics activities in school and students' concerns about their performance in mathematics. After collecting the data using these instruments and analyzing the data, Wigfield and Meece compared the covariance matrices of the younger (6th through 9th grade) and older (10th through 12th grade) students. The test indicated that the matrices were invariant across the age groups. The Goodness-of-Fit Index (GFI) for this test was .98 for the younger students and .93 for the older students. Wigfield and Meece found that the covariance matrices for boys and girls were similar. The GFI was .96 for girls and .97 for boys.

Another type of data analysis that Wigfield and Meece undertook was to weigh the MAQ items. Using the weighted MAQ items, Wigfield and Meece created scales based on the negative affective reactions and the worry factors. The alphas were .82 for the negative affective reactions scale and .76 for the worry scale. In almost every case, the correlations of the negative affective reactions scale and other scales were higher than were the correlations involving the math worry scale. Wigfield and Meece also analyzed the variances in order to assess age and gender differences in the two scales. On the math worry scale, the grade-level main effect was significant. No grade-level effects were observed on the negative affective reactions scale. On the negative affective reactions scale, girls reported experiencing significantly more negative affect about mathematics than boys. No gender differences were observed on the worry scale, and there were no interactions of gender and grade on either scale.

Wigfield and Meece claim that different components of math anxiety can be distinguished and that they are similar in younger and older children and in boys and girls. They also claim that math anxiety should be conceptually distinguished from perceptions of math ability. In addition, the anxiety that students report represents a lack of confidence in mathematics, as well as negative affective reactions to mathematics. Wigfield and Meece found that there were no differences in the structure of boys' and girls' responses to the MAQ. Boys and girls also did not differ in their reports of math worry. However, girls reported experiencing more negative affective reactions to mathematics than did boys.

Critique of study 1

There are several positive things about Wigfield and Meece's study. First, the study has contributed something to the field of mathematics education because of the relatively new dimension of anxiety that Wigfield and Meece have studied, the cognitive component of math anxiety. Second, in accordance with the findings in the study, Wigfield and Meece have put forward a suggestion to schools. They write, "We ... suggest that intervention programs to alleviate the negative effects of math anxiety ... should be implemented during the elementary school years"(p. 215). I am sure that such intervention programs would develop positive attitudes in the students, towards mathematics. Third, this research study is backed by an extensive literature review. Wigfield and Meece cited 19 studies in order to justify the undertaking of the study. They systematically unveiled what has been done in the area of math anxiety in order to distinctly reveal the 'edge' of knowledge in this area. This clearly delineates what is known from what is not known. In their discussion, Wigfield and Meece give details as to how far they have 'pushed' the work. In other words, they clearly see where they started and how much ground they have covered and are able to see what needs to be done next. They suggest that future researchers should explore more fully the links between math achievement values and anxiety.

Another strong point of the study is the great detail they include in describing the MAQ. Wigfield and Meece give adequate details of this instrument and present all 11 items in the instrument. In addition, the instrument was developed by Wigfield and Meece and they pilot-tested it in order to make sure that it was suitable for the study. Furthermore, Wigfield and Meece give a very clear reason for their decision to use the SAQ. The instruments they used were appropriate in accordance with the three questions that they set out to investigate. Most researchers have used the MARS in anxiety research, but as Wigfield and Meece argue, MARS is primarily a measure of negative affective reactions to mathematics. That is the reason why they used the MAQ, which captured the negative affective reactions to doing mathematics activities in school as well as the students' concerns about their performance in mathematics.

This study by Wigfield and Meece is not without fault. One severe weakness of the study is the way they generalize the results of the study, especially considering that the sample was not representative of the student population world wide. Their sample was not representative of the student population world wide because, as they put it, "classrooms at each grade level were chosen randomly from among the classrooms whose teachers volunteered..." (p. 211).

As we are aware, an unrepresentative sample limits the generalizability of results. Wigfield and Meece give details of the sample size and the type of students in the study. Unfortunately, they do not explicitly describe what the students did in the study. I am also surprised with their use of the word "approximately" in referring to the number of students who participated in the study. They write, "The year 1 sample consisted of approximately 740..." (p. 211).

Another weakness is that although the tables of results that Wigfield and Meece provide make the report clear, for one of the analyses they did not provide the ANOVA tables. In addition, details of the analysis of results are not fully provided. For example, they write, " A two-factor solution best described the data (the first eigenvalues were .95, 1.98, and .85)." I feel that they should have given us a full picture of their analysis. Another weakness is that what they set out to do, does not clearly come out because it is crowded by references to the work already done. I think that after giving reasons why they were conducting this study, they should have stated clearly, numbering each question, what the study sets out to assess. This means then that the information needs to be reorganized.

The researchers used two instruments: SAQ and MAQ. Although they administered SAQ twice, they only used MAQ once during Year 2 of the study. Their analysis is based on Year 2 data. They do not explain why they did not use MAQ in Year 1, and one wonders why they had to do the study over a period of two years.

Description of study 2

The report of the second study opens with a discussion of the importance of mathematics in an "increasingly technological society and the unfortunate state of affairs that prevails...that many students fail to perform well in mathematics due to several factors"(p. 390). From this discussion, Aksu and Saygi develop a sound rationale for the study. They write, "One concept which increasingly explains poor mathematics performance is that of math-anxiety" (p. 390). They rely on research already done on anxiety to justify their pursuit of this study. They write, "Most of the researchers reported a general agreement that levels of math-anxiety negatively affect academic performance in mathematics"(p. 390). After discussing anxiety as a cause of poor performance in mathematics, they discuss what they call "intervention strategies" that have been used to overcome math-anxiety. Aksu and Saygi list the strategies as follows: individual-teacher counseling, slower instructional approach, corrected feedback, instructional games, small-group instruction, reinforcement, extra work and drill, remedial studies, programmed instruction, computer-assisted instruction, and increasing competence in mathematics. In the introduction, they cite over 18 references that culminate in a statement of the purpose. The purpose of the research study was to investigate the effect of a corrective feedback treatment on a special form of anxiety, math-anxiety, and to obtain information on the effectiveness of the treatment on different levels of math-anxiety.

The subjects were selected from 389 sixth grade students (12-13 years old) in the "Yakselis Lisesi" Ankara, Turkey. The 389 students were grouped according to their Mathematics Anxiety Rating Scale for Adolescent (MARS-A) scores into three groups: High-Math-Anxious (HMA), Average-Math-Anxious (AMA) and Low-Math-Anxious (LMA). According to the normative data they obtained, a value below the 30th percentile indicated low math anxiety and above the 75th percentile indicated high math anxiety. Only 88 HMA and 81 LMA subjects were used in the study. Students who had a score below 180 and above 243 were selected as LMA and HMA subjects respectively. The 169 subjects were randomly assigned to experimental or control groups. In the experimental group, there were 26 females and 21 males in the HMA group and 9 females and 33 males in the LMA group. In the control group, there were 13 females and 28 males in the HMA group and 17 females and 22 males in the LMA group.

Two instruments were used: Mathematics Anxiety Rating Scale-A (MARS-A) and Quizzes. The researchers had translated the MARS-A from English into Turkish, and then it was revised. Their MARS-A version had 84 items, 14 fewer than the English MARS-A version, and it had a split-half reliability of .93. The 14 items that were removed were considered unsuitable to the Turkish society or to the grade level. During the study, the subjects in the experimental group took eight quizzes. The quiz papers were returned with the missing items completed and the incorrect answers corrected. The control group did not take any quizzes.

The study was conducted in four phases: preassessment, formation of groups, feedback treatment, and postassessment. The treatment lasted for six weeks. Students in the control and experimental groups followed the same mathematics instruction. The preassessment was used to group the students as high, average, and low math anxious. The data were analyzed using ANOVA and t-tests for two independent and correlated samples. The second phase was the formation of LMA and HMA groups and the experimental and control groups. The experimental and control groups received instruction, but only the experimental group was subjected to eight quizzes. The quizzes, which lasted 10 to 20 minutes, were given at the end of each 90 minute class period, which were two 45 minute sessions plus a break.

Each quiz had three questions, and quiz papers were returned to the subjects with incorrect answers corrected and missing items completed and scored. After six weeks the MARS-A was readministered to the 169 students in the study.

The Pre-MARS-A mean scores of the experimental and control group subjects were not significantly different, $t(167) = .16$, $p < .001$. The two-way analysis of variance (ANOVA) on Post-MARS-A scores indicated significant differences, $F(1,165) = 259.77$, $F(1,165) = 8.51$, $p < .01$, for math anxiety levels and study groups respectively. A decrease in the Post-MARS-A scores of the subjects in the experimental group yielded a significant difference between the mean Post-MARS-A of the experimental group and control group. Comparison of Pre-MARS-A and Post-MARS-A mean scores of HMA and LMA subjects in the experimental group yielded a significant difference for only the HMA subjects. Aksu and Saygi also tested if there was any difference between the anxiety levels of the two sexes. A 2 by 2 analysis of variance applied to the anxiety levels and the sex of subjects in experimental groups for mean Post-MARS-A scores revealed that there was not significant differences between the Post-MARS-A scores for the two sexes.

Results of the study show that corrective feedback may cause a reduction only in the math anxiety level of HMA subjects. Aksu and Saygi say that their findings were consistent with the findings of Hawkins. They indicated that the failure to find a significant difference between the Pre-MARS-A and Post-MARS-A scores of the LMA subjects in the experimental group implies that the math anxiety level of the LMA subjects does not change whether or not they are exposed to corrective feedback treatment.

Finally, they discussed the implications of the study for mathematics teachers in Turkey. They wrote that teachers should be aware of the fact that some of the poor achievers in their classes may be victims of math anxiety and that corrective feedback may be employed as one of the effective ways of retarding the development of math anxiety or providing its cure. Aksu and Saygi recommend that several studies be done on the same issue using other grade levels, other school samples, and other content areas in mathematics. They also recommend a study concerning the effect of math anxiety on mathematics achievement, which compares the change in mathematics achievement of high, average, and low math-anxious female and male students after they areexposed to feedback treatment. Aksu and Saygi also suggest other areas that need to be researched in order to complete the story and "enlighten the educators" (p. 396).

Critique of study 2

The research method that Aksu and Saygi used is compatible with the purpose of the study. They use an experimental design so as to be able to check on whether a feedback treatment makes a difference in students' math anxiety. The results make sense in accordance with the procedure used and the purpose of the study. The conclusion is valid in accordance with the purpose of the study. The findings of the study are easy to pick out because of the way Aksu and Saygi presented the results. They presented the ANOVA table and a table of means. The rest of the results are presented in tables as well.

Aksu and Saygi give adequate information on how they developed the instrument. This is good because it would be useful to anyone who may be interested in conducting a similar study in which he or she has to use a language other than English. Another good thing about the study is the way Aksu and Saygi develop their rationale, moving from the importance of mathematics in society to the failure to perform due to numerous factors including math anxiety.

This study is a replication of studies that have been done in this area of math anxiety except for the use of sixth graders in Turkish schools. The study was necessary because whatever other people have found about this problem elsewhere, it does not reflect the state of affairs in Turkey. There could be factors typical of Turkey that would have effects in one way or another on math anxiety.

I think it would have been useful, in the rationale, to show how things have developed in that area of study, both internationally and nationally. Aksu and Saygi should have cited at least one study that was done on math anxiety in a language other than English. Other weaknesses of the study include the lack of clarity of the purpose of the study. Aksu and Saygi fail to specifically articulate the purpose of the study. They write, "The aim of the study is to investigate the effect of corrective feedback treatment as a special form of anxiety, math anxiety, and to obtain information related to the different levels of math anxiety"(p. 390). I think that they should have been more precise and stated that they were interested in age and gender differences. Another thing that is not clear about Aksu and Saygi's study is that we do not get enough details about the quizzes. We are not told how they were developed, who developed them, their validity, etc. This sort of information enables the reader to judge the reliability and the validity of the instrument used in the study. Another problem Aksu and Saygi have is that of generalizing the results. They write, "From the results of this study, it can be concluded that corrective feedback can cause a reduction only in..."(p. 396). This is not good enough because, as

pointed out earlier, the sample might not have been representative of all Turkish schools. In addition, Aksu and Saygi do not indecate anywhere in thier study whether the sample was randomly chosen or not. They only randomly assigned 169 subjects to the experimental and control groups. This assignment may not be important as long as the initial sample was not randomly chosen.

The study has another weakness concerning the length of the treatment. Why did they decide on six weeks and one mathematics topic? Why could it not be ten weeks or something else? I would predict that the longer the period of treatment, the greater the difference. This illustrates how one can manipulate research factors in order to obtain desired results.

In the conclusion of their study, Aksu and Saygi, did not explicitly state their findings concerning age and gender factors. Another weakness of the study is that Aksu and Saygi considered a number of different definitions for the term "math anxiety" and they succeeded in clearly showing that the term is defined differently by different authorities, yet they fail to choose a working definition for their study.

Comparison of the two studies

The two studies have in common the general area of interest, math anxiety, but are far different when it comes to what they set out to do. The level of sophistication in the instruments and the procedures used, the importance internationally and nationally, and the intended audiences of the studies were very different.

Wigfield and Meece's study is at the forefront of studies in the field of math-anxiety. One would say it is a pioneering study, whereas Aksu and Saygi's study is a replication of another study on math anxiety. Because of its groundbreaking nature, the Wigfield and Meece study needed a relatively new instrument, which had to be developed. This is a big contrast to Aksu and Saygi's study, which made use of an already existing questionnaire translated into a local language. I believe this means that Wigfield and Meece's study required more thinking and careful planning than Aksu and Saygi's study. I believe that it follows from the foregoing that Wigfield and Meece's study is internationally important. It breaks new ground in international research on math anxiety in contrast to the nationally important Aksu and Saygi study. I have no doubt that Wigfield and Meece's study is more sophisticated than Aksu and Saygi's study. The data analysis procedures used by Wigfield and Meece are much more advanced than those used by Aksu and Saygi.

Aksu and Saygi's report was easy to read. They did not use many technical words compared to the other study. It could also be due to the fact that the issues they were investigating are simple. I would say that Aksu and Saygi's study was well organized and reported more clearly than the other study, but I must also say that the discussion of Wigfield and Meece's study is much more elaborate than that of the other study. Between the two rationales for the studies, I find Wigfield and Meece's to be much more powerful, not so much because of the references, but in the way they "net" (capture) ideas, reveal the "loose ends" and then raise the research questions.

Aksu and Saygi's rationale is not very strong. Aksu and Saygi define the term math-anxiety, which is the key word in the study. I find that to be useful as these terms are used differently by different people. It is unfortunate that Wigfield and Meece did not define the term. Furthermore, the statistical procedures that both pairs of authors applied seem to be appropriate for each study, and both sets of conclusions concur with the rationales. It is unfortunate though that neither pair of authors could avoid the temptation of generalizing their findings despite the fact that both studies used samples that I would say were unrepresentative of the student population worldwide.

The time the studies took to be completed is another dimension of comparison. Wigfield and Meece had their study going for two years, whereas in the other study the treatment was applied for six months. In conclusion, I would say that overall, Wigfield and Meece's study is much more powerful than Aksu and Saygi's study.

References

Aksu, M. & Saygi, M. (1988). The effects of feedback treatment on math-anxiety levels of sixth grade Turkish students. *School Science and Mathematics, 88,* 390-396.

Wigfield, A. & Meece, J. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology, 80,* 210-216.

Computers are fantastic: in a few moments they can make a mistake so great that it would take many men many months to equal it. *M. Meacham*