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ABSTRACT

A study was conducted at an urban community college in California to investigate the relationship among students' incoming mathematics skills, as measured by an achievement test administered when they entered the college; their math test anxiety, as measured by the Math Test Anxiety Index administered at midterm in an introductory mathematics course; and their performance on the midterm examination in the same course. Scores on all three measures were available for 54 of the students enrolled in the four sections of the course. The study revealed significant correlations between: (1) high entering math scores and low math anxiety scores, and high anxiety and low entering math scores; (2) students' entering math scores and their scores on the midterm examination; and (3) students' math anxiety level and their math test performance, even when controlling for the factor of initial skills level. The study report includes a review of the literature on math anxiety and student performance. The Math Test Anxiety Index is appended. (HB)

A REFINEMENT OF THE RELATIONSHIP BETWEEN EXAMINATION PERFORMANCE AND MATHEMATICS TEST ANXIETY

SOCIETAL FACTORS SEMINAR

by

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ABSTRACT

A REFINEMENT OF THE RELATIONSHIP BETWEEN EXAMINATION PERFORMANCE AND MATHEMATICS TEST ANXIETY

The practicum's purpose was to investigate the relationships among incoming mathematics skills levels, test anxiety, and examination performance in the introductory mathematics area for students at a large, urban California Community College.

The concepts, definitions, problems, etiologies, intervention strategies, and related research in math anxiety were presented.

The study, performed with students in four sections of an introductory mathematics class, considered three variables, *viz.*, incoming math skills (IMS) (measured by a standardized test), postinstructional math skills (PMS) (measured by a comprehensive midterm exam), and anxiety level (MTAI) (measured by self-report on a specially-adapted anxiety measuring questionnaire). The latter was administered by the author just before the midterm examinations for the classes.

Based on an effectively 100% response rate, significant negative correlations between the IMS-MTAI and MTAI-PMS pairs, a significant positive correlation between the IMS-PMS pair, and a significant negative partial correlation between the MTAI-PMS pair controlling for IMS were obtained.

It was deduced that the higher the initial math skills level, the lower the reported math anxiety; the higher the reported anxiety level, the lower the student will score on the exam; the higher the initial skills level, the higher the student will score on the exam; and the higher the reported math anxiety level, the lower the math test performance regardless of initial skills level.

It was recommended that all educational institutions, no matter what level or how selective, institute effective math- and exam-anxiety reduction programs owing to the problem's prevalence and debilitating effects.

A REFINEMENT OF THE RELATIONSHIP BETWEEN EXAMINATION PERFORMANCE AND MATHEMATICS TEST ANXIETY

INTRODUCTION

This practicum's purpose was to investigate the relationships among incoming mathematics skills levels, test anxiety, and examination performance in the introductory mathematics area for students at a large, urban California Community College.

A goodly amount of literature has been devoted to test anxiety, especially as evidenced in mathematics students (for example, in Elmore, 1979; and Hendel, 1977). While several variables -- both in the cognitive and affective domains -- have been implicated in examination performance (Betz, 1978), little if any such literature apparently takes a covariance-type approach to the analysis of the data. It is therefore highly possible that much of the published literature provides fallacious or misleading results, having ignored a significant correlate to test anxiety (which, with its effects removed, may tend to decrement anxiety-reduction programs' effects). The correlate of concern here is initial skill level.

This practicum refined the approach to the relationship between exam performance and math test anxiety by controlling for the incoming math skills levels of the students.

The first part of the procedures employed here involved an assessment of participants' math skills level. (This took place prior to their enrollment in any math class at the college.) The students were subsequently assessed for their mathematics course anxiety level. Finally, math performance levels, as reflected by midterm examination scores, were obtained for all participants.

The relationships among the variables were investigated through correlative statistics.

BACKGROUND AND SIGNIFICANCE

It appears to be almost tautological to note that student examination performance is a function not only of level of knowledge, but of the student's state of mind at the time of the exam itself. It is not unusual to come upon a societal folkway which either recognizes, permits, or even encourages expressions and experiences of anxiety, especially in the area of disciplines with substantial computational emphasis (e.g., see Randolph, 1947, P. 76). In response to this, for example, the Los Angeles Valley College Learning Skills Center provided a workshop specifically aimed at math anxiety in 1981.

The problem of anxiety adversely affecting the experience and performance in the mathematics area is substantially pervasive and longstanding. Morris, in her article written for math teachers, notes that "It is not a new phenomenon that a large segment of the population fears mathematics" (Morris, 1981). Other authors, shifting orientation to the instructor, note that "Often, mathematics instructors feel they are fighting a frustrating battle against insurmountable odds. The incredibly high failure and drop-out rate is demoralizing" (Kogelman, Forman and Asch, 1981).

Math anxiety seems to be a rather juicy topic for comiseration among student groups. It may therefore play an int restingly significant role in student social networks, which have an important function in student success and retention in college (Kissler, Lara, and Cardinal, 1981).

It was for these reasons that this practicum was produced within the context of the Societal Factors module.

The areas in which math anxiety, general examination anxiety, and/or associated stimulus conditions appear to affect test performance are widely varied. For example, it has been indicated that peripheral cognitive and affective exam conditions modulate IQ scores (Katz, Henchy, and Allen, 1968; and Katz and Greenbaum, 1963); that test anxiety appears to affect chemistry grades (Rasor, 1981); and that anxiety may either be debilitating <u>or</u> facilitating in the math area as well as in other achievement-related pursuits (Alpert and Haber, 1960).

The terms, "math anxiety," "mathophobia," and others, are used to imply a typically debilitating affective reaction to a computational (or related) challenge. A rather straightforward definition of math anxiety was provided by two of its most empirically-oriented investigators, Richardson and Suinn. They describe the problem as " . . . involving feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems . . ." (Richardson and Suinn, 1972, P. 551).

A somewhat more ornate and operationalizable definition is provided by Tobias and Weissbrod, who note that " . . . math anxiety . . . was used to describe the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (Tobias and Weissbrod, 1980, P. 65). The physical correlates to the experience of math anxiety are also mentioned by Kogelman <u>et</u>. <u>al</u>., who provided the following in case study format: "Physical responses to mathematics were both common and severe. One participant found that her right arm became numb when she was asked to do mathematics. Another suddenly would start holding his breath when materials were distributed. Other frequently described symptoms of math anxiety were: an inability to focus on written material, headaches, backaches, stiff necks, queasy stomachs, sweaty palms, and diarrhea" (Kogelman, Forman, and Asch, 1981, P. 32).

Many theorists discuss the etiology of math anxiety, but there is no consistently-agreed-upon paradigm. This may be because of the high probability of multiple etiological factors leading to a functionally similar result. A rather common theme among the diverse theoretical body is that of previous punishment or otherwise "negative" experiences associated with math educators. According to Matheson (1977), it is usually the case that a math-anxious student will have in his or her past an experience where a math teacher "embarrassed" the student. In fact, Aiken (1976) notes that the instructor himself or herself is more influential than the curriculum with respect to attitudes toward mathematics.

A reasonably large body of research addresses the apparent sexual dichotomy with respect to the experience of math anxiety. The problem is substantially more often identified in females than it is in males. While the word, "identified" does not necessarily imply "prevalent," certain social role-related etiological factors appear to add power to the sexual dichotomy observed in math anxiety. According to Matheson

(1977), within the social context, mathematics is/was clearly a "male" domain. Intriguingly, this differentiation appears to be time-dependent. Fennema (1976), investigating this time-sex effect in math anxiety, found that in elementary school the sex differential in attitudes toward mathematics achievement was extremely small, but that by the time the students reached high school, the computational discipline was seen as a clearly male domain.

Reflecting further on the sex and time effects in math anxiety, Diener and Dweck (1978) investigated students' attributions with respect to the problem. They found that girls more often attribute their failure in math problem solving to a lack of intelligence, while boys attributed it to a lack of effort. These two quite different attributions would have substantially different implications for therapeutic intervention.

The theoretical underpinnings for those interventions which have already been promulgated have been through a number of iterations (and the dynamics continue). In the not-too-distant past, investigators and therapists would approach math anxiety as a unitary concept, and would generally tend to apply apparently simplistic interventions to overcome the problem. These interventions usually involved some kind of soothing of the students.

In 1977, Finger, Randy and Galassi postulated that math anxiety might have two components, viz., an emotionality response (made up of the transient physiological and affective arousal responses) and a set of cognitive responses (seen as more stable or enduring than transient and composed of what the authors called the "worry" responses). Adding power to this conceptual multiplicity of operating factors was the more recent work by Rounds and Hendel (1980). These authors took the most often used and investigated math anxiety measuring instrument (the Mathematics Anxiety Rating Scale, or "MARS," developed by Richardson and Suinn in 1972) and factor-analyzed it. They determined that two differentiable (yet nonorthogonal) factors were evident in the MARS, viz., "mathematics test anxiety" and "numerical anxiety." These two factors are not superimposable on the Finger et. al. dyad, and therefore add to the complexity of the problem of understanding math anxiety.

The Finger et. al. study indicated that one could indeed conceptually differentiate the cognitive and emotionality responses to test (and math) anxiety but that these factors simultaneously or serially interacted to the point where it is not worth treating them separately. Separate treatment led to nonsignificant differences.

The Rounds and Hendel pair might lend themselves to differential therapeutic intervention: Math anxiety alone can express its debilitating effects in the absence of formal tests, e.g., in the supermarkets without unit pricing.

Whatever the actual dynamics operating here, several interventions have been attempted (or at least suggested) with varying levels of apparent or demonstrated success.

Matheson (1977), in her overview of math anxiety reduction attempts, notes the three models most typically used in such interventions. The first is remediation, which she sees as best (most effective) when there is relatively little anxiety present but the person lacks the basic skills. The second general intervention category is said to be content manipulation, reportedly operationalized as mathematics laboratories, individualized instruction, mathematics games, and so forth. Third is the integrated approach, where mathematics coursework and psychological interventions are paired for maximal apparent effectiveness. As will become obvious shortly, Matheson's list is incomplete. For example, it misses those peripherally-related interventions which still, at least conceptually, should help decrease mathematics anxiety. An example of these would be "psychological" (affective, in this sense) interventions which do not directly incorporate math concepts. Nevertheless, it may be useful to categorize published intervention techniques under the set of "augmented" Matheson rubrics.

Dellens (1979) recommended four strategies for a learning center to use in combatting math anxiety. He suggested that the centers offer noncredit review classes (remediation); provide one-hour "focus groups" centered on study techniques (peripherally-related); sponsor informal groups dealing with math anxiety (affective); and make desensitization tapes available to anxious students (affective).

Kogelman, Forman, and Asch (1981) recommend relaxation exercises (affective), specifically aimed at reducing the physical reactions to math noted earlier.

Morris (1981) recommends several interventions: to create a "positive, supportive classroom atmosphere" (integrated approach); to stress understanding of the thought process and deemphasize, e.g., rote (integrated approach); to "dispel the 'math mind' myth" through, e.g., an instructor being able to admit that he or she doesn't know how to do a given computation (affective); to reduce tension and pressure in math classes by, e.g., eliminating timed tests (affective); and by providing new, positive math experiences (content manipulation).

This last technique has its theoretical basis in classical conditioning theory, where associations of good feelings (e.g., through success with math) may make further math attempts more palatable. This "success by design" approach is also mentioned by Tobias and Weissbrod (1980), who mention various math anxiety programs that purposefully provide problems where participants can be successful and where participants are permitted to reject difficult problems.

Most of the techniques mentioned thusfar were actually merely recommended by the authors under the a priori assumption that they would be effective. Unfortunately, little quantitatively scientific literature was available with respect to specifically mathematics test anxiety. However, overall test anxiety reduction studies are available. The studies about to be described focused on psychology test anxiety.

Quantitative and scientifically-acceptable publications include those of Goldfried (1971) and Suinn (1977).

The Goldfried methodology modified pure systematic desensitization procedures by providing three different relaxation procedures (cuing relaxation with deep breathing, cue-controlled relaxation, and focus on and "relaxing away" areas of felt tension). The anxiety heirarchy (standard in systematic desensitization therapy) here included 15 items; nine of these were directly related to test anxiety.

Suinn's (1977) technique was similar to that of Goldfried except that, instead of a 15-item heirarchy, two to three "personal scenes" were developed, all of which depicted very high anxiety-provoking images.

The Goldfried and Suinn techniques also differed in that, with the former, when tension was felt, the participants would signal that experience but continue their relaxation efforts. In the Suinn techn[illegible], by contrast, the therapist would initially indicate whe[illegible] relax and when to terminate scenes, but as the therapy progressed the responsibility of relaxation initiation and scene/visualization termination was shifted to the client.

Deffenbacher, Michaels, Michaels, and Daley (1980) compared the Goldfried and Suinn techniques for effectiveness. They found both treatments showed significant decreases in test anxiety directly posttreatment and at a six-week follow-up. However, when "nontargeted" (nonpsychology test) anxiety reduction was measured, it was found that only the Suinn technique was effective directly after the treatment. Interestingly, at the six-week follow-up, both techniques were shown to be effective against nontargeted anxiety. Deffenbacher et. al. suggested that there may be some kind of "consolidation" effect operating, where anxiety reduction interventions may generalize only after a time delay. This kind of result points up the complexity of the investigation of test anxiety.

Clearly, the field of math anxiety reduction and general test anxiety reduction is being subjected to intensive study. The more refined the scientific investigative approaches used to understand and ultimately defeat such anxiety, the more rapidly such triumph is destined to occur. The sundry interventions currently promulgated as effective need to be subjected to more controlled scrutiny before resources are poured into their institution.

The present study seeks to assist in the quest for proper scientific inquiry; to identify appropriate variables and their interactions in the investigation of mathematics and math exam anxiety.

PROCEDURES

1. Subjects

The subjects for this study were comprised of all entering day students at the author's California Community College taking the introductory mathematics course Math 29 from that instructor teaching the modal number of sections of Math 29.

Math 29 is the lowest-level mathematics credit course available at the college. Its title is, "The World of Numbers."

The rationale for having limited the sample to one instructor's classes involved the obviation or at least minimization of differential motivational and anxiety-provoking or reducing effects related to the instructor's personality and technique.

The choice of an introductory class as opposed to one more advanced derived from the desire to maximize the skills level heterogeneity of the sample.

2. Incoming Mathematics Skills (IMS) Variable

All entering day students at the institution are required to take the Employee Aptitude Survey-2 (EAS-2) Test for assessment of their incoming mathematics skills levels (Psychological Services, Inc., 1980). EAS-2 test scores for the sample were obtained from the students' counseling record cards.

3. Postinstructional Mathematics Skills (PMS) Variable

This measurement consisted of the total number of points obtained on the first midterm examination in the Math 29 class for all subjects.

The rationale for taking the first midterm exam was that subject self-selection (operationalized as dropping out after evidence of poor work) was minimized. This exam was the first "comprehensive" one given in the Math 29 classes. Again, heterogeneity of the subject group was desired. Additionally, the confounding factor of "test-brightness" was minimized.

4. Anxiety Level Variable

The Math Test Anxiety Index (MTAI) was created by adapting the "Belief and Feelings about Chemistry" questionnaire (Rasor, 1981) (see Appendix). The only changes were the replacement of references to chemistry with references to mathematics.

A participant's anxiety score was computed by summation of all responses to negatively-phrased questions (such as, "When I don't do well on a difficult item at the beginning of an exam, it tends to upset me so that I block on even easy questions later on") plus inverted summation (that is, based on reversed scaling) of responses to positively-phrased questions (such as, "Nervousness while taking a test helps me do better").

The MTAI was originally planned to be administered by the instructor. In discussions with the instructor it was decided that, to underscore the lack of relationship between a student's answers on the MTAI and his/her grade in the course, the writer (instead of the Math 29 instructor) would administer the MTAI.

The students were forewarned that a survey form having no effect on their grades would precede their midterm, and that the college researcher would be administering the instrument.

For each class (of which there were four), the instructor introduced the author who thereupon told the students that the instrument was part of a research project. Students were reminded that their filling out of the instrument would have no effect on their grades for the class. MTAIs were passed out and students took whatever time they needed to complete the MTAI (typically about seven minutes).

5. <u>Statistical Analysis</u>

Using formuli from Guilford and Fruchter (1973), Pearson product-moment correlation coefficients were computed for all three combinations of the three variables taken two at a time. Partial correlation coefficients were then computed for the MTAI-PMS distributions, thereby removing the effects of IMS.

RESULTS

1. Response Rates

The total subject pool as defined (at the time of MTAI administration) by the total number of students enrolled in all the Math 29 classes of the instructor teaching the modal number of such classes was 113 students.

Of these, 54 (48.7% of the total) had IMS data available in the counseling office files. Since listwise deletion of missing data was the option chosen for this essentially correlational study, the useful potential subject pool was comprised of these 54 students.*

MTAI data were collected on all 54 of these students, for an effective response rate of 100%.

2. Correlational Results

The top portion of Table 1 presents the simple Pearson Product-Moment Correlation Coefficients under study along with their associated t tests of significance at $\alpha = 0.05$. The bottom portion of Table 1 presents the obtained partial correlation coefficient (Guildord and Fruchter, 1973) and its Z-test for significance (op. cit., P. 145 and 314).

*In the four Math 29 sections, the percents of students without IMS scores were 46, 52, 53, and 54 percents. A Chi-Square analysis of these percents yielded $\chi^2 = 0.76$

TABLE 1

CORRELATIONAL RESULTS AND TESTS OF SIGNIFICANCE*

Designation	Correlated Variables	r_{obt}	t_{obt}	df	t_{crit}	sig?
r_{23}	IMS - MTAI	-0.463	-3.803	53	2.007	Yes
r_{12}	MTAI - MIDTERM	-0.630	-5.906	53	2.007	Yes
r_{13}	IMS - MIDTERM	0.266	2.009	53	2.007	Yes

$r_{12.3} = -0.593$; $\sigma_{r_{12.3}} = 0.139$; $Z = -4.266$

(significant at $\alpha = 0.05$)

*The higher the MTAI score, the greater the reported anxiety.

All the coefficients are signifcant at $\alpha = 0.05$. Since numerically larger MTAI scores represent higher levels of math anxiety, the following verbal interpretations of the coefficients apply:

A. That there is a statistically significant correlation between a student's initial mathematical skills level and his/her reported experience of test anxiety before a mathematics exam; that the higher the initial math skills level, the lower the reported math anxiety;

B. That there is a statistically significant correlation between a student's reported anxiety level and his/her performance on a mathematics examination; that the higher the reported anxiety level the lower the student will score on the exam;

C. That there is a statistically significant correlation between a student's initial mathematics skills level and his/her performance on a mathematics examination; that the higher the initial skills level the higher the student will score on the exam; and

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(footnote from Page 17, continued) with df = 3 (Hardyck and Petrinovich, 1969). Since $\chi^2_{crit} = 7.82$ at $\alpha = 0.05$, one would conclude that there was no significant relationship between class membership and IMS score availability.

D. That there is a statistically significant correlation between reported mathematics anxiety level and mathematics test performance even when the factor of initial skills level is controlled for; that the higher the reported mathematics anxiety, the lower the mathematics test performance (essentially) regardless of initial skills level.

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

The effects of both specifically mathematics anxiety and general test anxiety have been clearly demonstrated in the literature to have the potential for being extremely debilitating with respect to examination performance. Myriad anxiety-reduction programs have been generated to address this educational problem.

Understanding and accurately appreciating the phenomenon in question requires the empirical validation of a number of related assumptions. Several of these have been validated in this study.

For example, the inverse relationship between a student's initial mathematics skills level and his/her reported degree of math anxiety -- that the more embellished the student's arsenal of computational abilities the more at ease he/she feels in a math exam -- has been demonstrated here. And the greater the reported mathematics anxiety, the worse one scores on a mathematics examination.

It also appears that one's "advantage" of coming into a computationally-oriented class with demonstrably better mathematics skills than one's peers is maintained, at least to midterm. The instructional interventions between the initial class meeting and the comprehensive midterm examination, while they <u>may</u> have raised the skills levels of all students in the class,* apparently did not equalize the skills levels. That is, according to the significant negative correlation between initial skills level and comprehensive midterm examination performance, the skills <u>differential</u> among students apparently was not breached.

A major point of this study was to see if, having controlled for (statistically removed the confounding effects of) initial skills level, the debilitating effects of reported math anxiety would still be negatively correlated with examination performance. The significant negative partial correlation coefficient between reported anxiety and midterm examination scores shows that, indeed, regardless of incoming skills level, examination performance suffers in the context of related anxiety.

The implication here is clear, and it speaks to the critically important role effective anxiety-reduction programs can and should play in the educational arena. Since mathematics anxiety (and test anxiety in general) are demonstrably prevalent; since, according to the literature, the

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*Not investigated here.

pathology's tentacles reach so many students (with an observed slightly greater effect on teenage and older females); and since successful performance in mathematics exercises and examinations is a pedagogically and androgogically sound reinforcement technique for skills inculcation and development; the quest for and institutionalization of effective anxiety reduction programs is of tremendous importance.

It is therefore recommended that such programs be identified and employed at <u>all</u> educational institutions. The last phrase is quite important here: Highly selective grammar schools, junior and senior high schools, colleges, universities, and departments need to be just as concerned with reducing the anxiety levels of their students as do essentially "open door," nonselective educational institutions. High anxiety levels <u>are</u> associated with lower test scores, and initially competent students are <u>not</u> immune from the debilitating effects of mathematics and general test anxiety.

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A P P E N D I X

MATH TEST ANXIETY INDEX

MATH TEST ANXIETY INDEX

Instructions: Rate EACH statement below on how strongly you agree or disagree using the following scale:

1	2	3	4	5	6	7
Very strongly disagree	Strongly disagree	Disagree somewhat	Neutral	Agree somewhat	Strongly agree	Very strongly agree

____1. I'm afraid that I might not do very well in this course.

____2. Looking at formulas that I don't understand yet makes me feel nervous.

____3. I'm worried that this course will be a bad experience for me.

____4. I feel just as comfortable in this math class as I do in any of my other classes.

____5. I'm confident that by the end of the semester I will be able to discuss math intelligently.

____6. I'm afraid that my work in this course won't earn the grade I want.

____7. I start to feel tense when I read my math book.

____8. When I think about taking a major exam in this course I feel nervous.

____9. I am confident that I will benefit a great deal from this course.

____10. Sometimes when I am trying to make sense out of a mathematical formula or equation I get confused and can't think clearly.

____11. I believe that I will master most of the material presented in this course.

____12. I worry about this course a lot even when I am doing other things.

____13. I am afraid that I may not even pass this course.

____14. I am looking forward to getting involved in the more advanced part of this course.

____15. I sometimes feel that I just don't have the background necessary to succeed in this course.

____16. I expect to understand all of the reading without too much trouble.

____17. I sometimes lose sleep thinking about my math course.

____18. I'm concerned that I will not be able to follow the lectures very well.

____19. I worry about not being able to get caught up if I miss a class.

____20. Math is inherently a very difficult subject.

KEY to scoring Math Test Anxiety Index:

The following question numbers reflect "negatively phrased questions," whose numerical scores (from the 1-to-7 scale atop the MTAI) were added without alteration:

1, 2, 3, 6, 7, 8, 10, 12, 13, 15, 17, 18, 19, 20.

The following question numbers reflect "positively phrased questions," whose numerical scores (from the 1-to-7 scale atop the MTAI) were reversed* and then added to the sum of the scores from the questions identified in the preceding paragraph:

4, 5, 9, 11, 14, 16.

*REVERSAL KEY:

Number assigned by participant:	1	2	3	4	5	6	7
Number added for sum:	7	6	5	4	3	2	1