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ABSTRACT

This study investigated changes in mathematics anxiety levels among future teachers in two different mathematics materials and methods classes. The changes were a function of using (1) Bruner's framework of developing conceptual knowledge before procedural knowledge, and (2) manipulatives to make mathematics concepts more concrete. The study included 87 novices who took elementary or intermediate level mathematics teaching classes. Two strategies were used to gather data at the beginning and end of each quarter. First, future teachers took home and completed a 98-item questionnaire, the Mathematics Anxiety Rating Scale (MARS) during the first week of class. The treatment was a hands-on approach to teaching mathematics with manipulatives in the methods and materials course. During the 10th week of the quarter, they completed the MARS again. Second, some of the factors influencing levels of mathematics anxiety were determined using questionnaire-guided narrative interviews. The researchers also observed the preservice teachers in the methods and materials classes and had informal discussions with them. Multivariate analysis of variance revealed a statistically significant reduction in mathematics anxiety levels between the fall and winter quarters. Pretest-posttest raw score differences were highly significant for winter, spring, and summer quarter classes, but not for fall quarter classes. (Contains 9 tables and 39 references.) (Author/SM)

A COMPARISON OF PRESERVICE TEACHERS' MATHEMATICS ANXIETY BEFORE AND AFTER A METHODS CLASS EMPHASIZING MANIPULATIVES

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ABSTRACT

The changes in levels of mathematics anxiety among future teachers in two different mathematics materials and methods classes were investigated. The changes were a function of using: (a) Bruner's framework of developing conceptual knowledge before procedural knowledge, and (b) manipulatives to make mathematics concepts more concrete. The sample included 87 novices at Athens State College, Athens, Alabama who took classes entitled ED 324 "Mathematics for the Young Child" and/or ED 424 "Teaching Mathematics in the Intermediate Grades." Two strategies were used to gather data both at the beginning and ending of each quarter. First, future teachers completed 98-item, Likert-type questionnaires. Second, some of the factors that influence the levels of mathematics anxiety were determined through the use of questionnaire-guided narrative interviews. Multivariate analysis of variance was employed as the quantitative measure for comparing mathematics anxiety both at the beginning and ending of the quarter. Data revealed a statistically significant reduction of mathematics anxiety levels ($p<.05$). Tukey's HSD was used to determine that a significant difference occurred between the Fall and Winter Quarters. Results of the study have implications for teacher education programs concerning the measurement of mathematics anxiety levels among future teachers and the determination of specific contexts in which that anxiety can be interpreted and reduced.

INTRODUCTION

Many studies now show that too many students in the United States have a moderate level of procedural knowledge of mathematics, and an even lower level of conceptual knowledge. Therefore, mathematics power is diminished and anxiety is increased. Martinez (1987) wrote that "anxiety may be a greater block to math learning than supposed deficiencies in our school curricula or teacher preparation programs" (p. 125). Effective mathematics teachers know that they must follow the modes of learning as presented by Bruner so that students are provided with concrete experiences that form the basis for pictorial and symbolic mathematics learning. The purposes of this paper will be: (a) to present quantitative and qualitative research concerning the effects of mathematics anxiety among future teachers, and (b) to discuss ways in which mathematics anxiety can be reduced among future teachers and their future students. The research will present results from four consecutive quarters at an undergraduate institution.

Mathematics Anxiety Defined. Mathematics anxiety is more than a dislike toward mathematics. Smith (1997) characterized mathematics anxiety in a number of ways, including: (a) uneasiness when asked to perform mathematically (divide up the restaurant check), (b) avoidance of math classes until the last possible moment, (c) feelings of physical illness, faintness, dread, or panic, (d) inability to perform on a test, and, (e) utilization of tutoring sessions that provide very little success.

Reys, Suydam, and Lindquist (1995) illustrated math anxiety and mathophobia as a gorge that separates the concrete (modeling, manipulating, and communicating) from the abstract (generalizing, representing, symbolizing, and communicating). In that gorge exists poor performance on math tests, misunderstandings, uncertainty, apathy, classroom behavior problems, lack of confidence, low motivation, and a strong dislike of mathematics. Wright and Miller (1981) concluded that mathematics anxiety is directly related to perceptions of one's own mathematical skill in relation to skills in other subject areas.

Results of Mathematics Anxiety. "Math-anxious teachers can result in math-anxious students" (Martinez, 1987, 117). Sovchik (1996) offered the relationship between mathematics anxiety and future students as one that is passed from teachers to students. Teachers, Sovchik warned, must first examine the symptoms of math anxiety to see if they themselves exhibit any. In addition to that, teachers were encouraged to incorporate strategies in the classroom to alleviate mathematics anxiety altogether. In a study conducted by Scholfield

(1981), teacher attitudes were directly linked to student performance in and student attitudes toward mathematics. Results indicated that high-achieving teachers produced high-achieving students with least-favorable attitudes toward mathematics. Those teachers who were classified middle- or low-achieving in their abilities to teach mathematics had students whose attitudes were the most-favorable, yet maintained the lowest achievement scores.

Cruikshank and Sheffield (1992) wrote that they were unconvinced that elementary school children suffer from mathematics anxiety. Instead, they argued that teachers, who fail to implement seven important measures, cause their students to learn math-anxious behaviors. These measures include teachers who: (a) show that they like mathematics; (b) make mathematics enjoyable; (c) show the use of mathematics in careers and everyday life; (d) adapt instruction to students' interests; (e) establish short-term, attainable goals; (f) provide successful activities; and (g) use meaningful methods of teaching so that math makes sense. In addition to these measures, Reys, Suydam, and Lindquist (1995) suggested de-emphasizing speed tests or drills and avoiding competition among students in order to further reduce the chances of mathematics anxiety. They also added that communicating about mathematics and reflecting on the mathematics events that occur in the classroom would enhance mathematical power.

From an academic standpoint, Post (1992) warned that negative attitudes toward mathematics can produce negative results in mathematics due to the reduction of effort expended toward the math activity, the limited persistence one exerts when presented with an unsolved problem, the low independence levels one is willing to endure, and whether or not a certain kind of activity will even be attempted. Dutton and Dutton (1991) suggested that attitude towards mathematics influences how often mathematics is used, the willingness to pursue advanced work in mathematics, and even the choice of prospective occupations. For the purposes of this study, preservice teachers were made aware of the symptoms of mathematics anxiety and the prevalence of it among elementary education majors and in schools.

Research Involving Math Anxiety. The Curriculum and Evaluation Standards for School Mathematics was published by the National Council for Teachers of Mathematics (NCTM) in 1989 as a response to the call for reform from reports such as Everybody Counts (National Research Council, 1989). The NCTM Standards call for a focus on the process, rather than the product of mathematics so that students can become better, persistent problem-solvers in their everyday lives. The NCTM states that students need to value mathematics and be able to manipulate, see, and communicate mathematics (both orally and in writing).

The Foundation for Advancements in Science and Education (FASE) (1997) reported that of the 500 elementary school students they surveyed in five

U.S. cities, 90 percent said that they really want to be good at math, and 75 percent said that math is important and that you need to be good in math to get a good job. However, barely a third wanted a job that uses math, and nine out of ten thought that math is boring. FASE believes that television may be the culprit for American students performing below their counterparts in other developed countries on tests of mathematics achievement. While television may be the cause, however, they have demonstrated with research that classroom television using *The Eddie Files* can enhance positive feelings about mathematics and science. Each episode of *The Eddie Files* includes three important elements: (a) classroom lessons involving real students, (b) documentary interviews with the professionals who use the concepts from the lessons, and (c) "Eddie", a fictional 11-year-old student who is keeping files of what he wants to be when he grows up.

Research has indicated that particular groups of students have higher mathematics anxiety levels. Students who are female (Betz, 1978; Calvert, 1981) and students who have previously received lower than expected or lower than average scores in math classes have tended to have higher levels of math anxiety (Battista, 1986; Betz, 1978; Calvert, 1981). Other studies have shown no significant relationship between gender and mathematics anxiety (i.e. Widmer & Chavez, 1982). Kelly and Tomhave (1985) studied elementary education majors' anxiety levels as compared to four other math-anxious college groups and found the education majors to have the highest anxiety levels.

Teacher variables have been studied to determine effects upon student achievement and mathematics anxiety. Van de Walle (1973) investigated third- and sixth-grade teachers' formal (mathematical emphasis on rote memory) and informal (probing and trial-and-error) perceptions of mathematics. Findings indicated a positive effect on students' mathematical comprehension when teachers exhibited informal perceptions and evidence of positive attitudes, such as low mathematics anxiety. Furoto and Lang (1982) studied teaching strategies designed to foster students' positive self-concepts and their subsequent effects on attitudes, anxieties, and achievement in mathematics. The study revealed a positive relationship between students' achievement and teacher attitudes, as well as, a reduction in mathematics anxiety levels as a result of positive self-concepts.

Teacher attitudes have been a major focus of many research studies involving mathematics anxiety. Teague and Austin-Martin (1981) investigated teachers' mathematics anxiety and its relationship on teaching performance. The results indicated a correlation between the two variables. In addition, mathematics methods courses were found to reduce anxiety towards mathematics, but not significantly change attitudes towards mathematics. Similarly, Olson and Gillingham (1980) concluded from their study that attitude toward mathematics and mathematics anxiety were not significantly related. On the other hand, Arem (1993), structured a popular self-help book, on the premise that a positive attitude toward self and mathematics serves as a solid foundation for overcoming math anxiety.

Investigators have found that treating math anxiety with counseling (Hendel & Davis, 1978), hypnotherapeutic restructuring, and desensitization (Trent, 1985) have been effective at reducing mathematics anxiety. Mathematics performance, however, has not been shown to significantly increase. Other strategies have included study skills training and relaxation training (Bander, Russell, & Zamonstny, 1982).

Studies examining preservice teachers' mathematics anxiety have also been conducted. Kontogianes (1974) found that a self-paced program in which preservice teachers participated in lectures, group sessions, and individualized tutoring from the professor, positively affected the preservice teachers' mathematics achievement, retention, and attitude. Tishler (1980) focused on the element of remedial mathematics instruction and found that preservice teachers' attitudes towards mathematics were positively changed in the 13-week treatment. Sovchik, Meconi, and Steiner (1981) found a reduction in mathematics anxiety among preservice elementary teachers after participating in a mathematics methods course. The majority of preservice teachers who participated in Chapline's (1980) study indicated a reduction of mathematics anxiety after inductive approaches to problem-solving, test preparations designed to reduce anxiety, and student logs of attitudes and perceptions. Therefore, for the purposes of this study, heavy emphasis was placed upon the relationship between preservice teachers' attitudes and the resultant effect upon their future students.

Overcoming Math Anxiety. It is believed by many that effective mathematics instruction will ward off the development of mathematics anxiety. According to qualitative interviews with teachers across the United States, effective mathematics instruction is "learning in action" (Seymour, 1996, 43). That action often includes games, simulations, problem-solving activities, discoveries, and challenges. Teachers reported that the use of these manipulatives and real-life mathematical events helped them make math meaningful; the sum of which is "math minus misery" (p. 43). Dutton and Dutton (1991) found that both teachers' and students' unfavorable feelings toward mathematics centered around the lack of emphasis placed upon understanding, teaching that is detached from real-life experiences, and paper-and-pencil drills. They encouraged an emphasis of learning with manipulatives and authentic learning situations that mimic mature situations of dealing with mathematics.

Smith (1997) simply stated that math anxiety is a behavior that has been learned and can be "unlearned" through "positive self-talk" (p. 2). Kellough (1996) offered that one of the 50 ways to provide a supportive learning environment for mathematics and science is for the teacher to avoid being "uptight and anxious." Furthermore, careful preparation of lessons and a focus on their implementation are suggested as the primary ways to prevent a contagious anxiety toward these subjects. Schwartz and Riedesel (1994) offered that the teacher's preparation for instruction should be two-fold to encompass the affective aspects of the lesson as well as the cognitive.

Using appropriate and concrete instructional materials is necessary to ensure that children understand mathematical concepts. Dutton & Dutton (1991) recommended that the teaching for understanding should follow Bruner's theory of cognitive stages and, thus, involve the use of concrete material, moving on to the semi-concrete or pictorial, and then finally, exploring new ways to attack problems symbolically. Studies (i.e. Widmer & Chavez, 1982) have shown that elementary school interns' and teachers' anxiety levels are significantly reduced when an emphasis is placed upon understanding. Determining what is appropriate for instruction involves an evaluation of what developmental stage into which the child's development falls. Furthermore, Grouwns (1992) claimed that the use of concrete materials in the classroom could all but eliminate math anxiety.

Therefore, for the purposes of this study, heavy emphasis was placed upon concrete learning of mathematical content by use of manipulatives during the mathematics methods and materials courses for preservice teachers. This served a two-fold purpose. First, the concrete experiences aided in preservice teachers having a better understanding of the mathematical concepts and purposes for procedures. Secondly, using manipulatives assisted the preservice teachers in learning how to teach with more than just modeling a procedure on the chalkboard, for example.

The Study

Data Collection: Likert-type scales have often been used to measure attitudes toward mathematics (i.e., *Arithmetic Attitude Scale*, 1961, *Attitude toward Arithmetic Scale* (1968), *Attitude toward Mathematics Scale*, 1974, *Mathematics Attitude Scale*, 1974, and *Survey of School Attitudes*, 1975). The *Mathematics Anxiety Rating Scale* (MARS) (Richardson & Suinn, 1972) is a 98-item, self-rating scale which may be administered either individually or to groups. Each item on the scale represents a situation which may arouse anxiety within a subject. The subject is to decide on the degree of anxiety aroused, using the dimensions of "not at all", "a little", "a fair amount", "much", or "very much." The MARS test-retest reliability coefficient was first determined at 0.78 after two weeks

($p<.001$). The authors reported that after receiving treatment for mathematics anxiety, MARS found a reduction of anxiety levels from 50 to 70 points. The mean MARS score was 187.3 (N=119, SD=55.5) at the pretest and 179.9 (SD=55.9) at the posttest.

The *Mathematics Anxiety Rating Scale* (MARS) was used as the quantitative instrument in this study. Preservice teachers were given the pretest to take home and complete during the first week of class. The treatment was a hands-on approach to teaching mathematics with manipulatives in the methods and materials courses for preservice teachers. During the tenth week of the quarter (the last week) the subjects were given another copy of the MARS and asked to bring it back at the end on the last day of class that week.

The pretest MARS score was subtracted from the posttest MARS score for each subject to reveal a difference score. This difference score was reported as a positive or negative number in Tables 1 through 4. A negative difference score meant that the subject's mathematics anxiety was decreased by that much. A positive difference score meant that the subject's mathematics anxiety actually increased during the quarter.

The qualitative measurement included informal observations of preservice teachers in the methods and materials classes, informal discussions with them, and informal interviews that were either initiated by the professor (the primary researcher in this study) or episodes that were initiated by preservice teachers. The latter were generally in response to questions or concerns that were expressed from the preservice teachers either individually or in small groups about the teaching of mathematics, their own mathematics backgrounds, or their class teaching assignments.

Results. Tables 1 through 4 provide individual pretest, posttest, and difference scores (posttest minus pretest). These tables also show overall means for pretests, posttests, and difference scores. Table 5 shows the raw score means by group (quarter). This table reveals that the greatest difference scores existed between Fall 1996 (-14.9167) and Winter 1996 (-48.0588). This means that the average reduction of mathematics anxiety was significantly greater in the Winter Quarter than in the Fall Quarter. A possible reason for this could be that Fall Quarter 1996 was the professor's first quarter to teach at that particular college. Table 6 provides the t-test comparisons of pretest and posttest raw scores by quarter, and illustrates that Fall Quarter is significantly different from the other three quarters. This means that the reduction of mathematics anxiety was not as great during the Fall Quarter as compared to the other three quarters.

Tables 7-A, 8-A, and 9-A present the MANOVAS for dependent variables across groups (quarters). Tables 7-B, 8-B, and 9-B present the individual t-test comparisons of pretest and posttest raw scores by quarter. For example, Table 7-A presents the MANOVA for all four quarters with the dependent variable as "gain" or the differences between pretest and posttest scores; Table 7-B shows the post-hoc comparison, using Tukey's Honestly Significant Differences (HSD) to determine where actual significant differences lie when the overall comparison is significant. Fall Quarter evidenced no significant differences; all other quarters evidenced highly significant differences.

Summary of Results:

1. After comparing group means for the Pretest and the Posttest scores, it was found that overall math anxiety was significantly reduced ($p<.05$). In addition, Pretest-Posttest raw score differences were highly significant for Winter, Spring, and Summer Quarter Classes; Fall Quarter class score differences were not found to be significant.

2. MANOVA across classes for Gain (difference) raw scores yielded significant F ratio ($p=.0449$) with post hoc comparisons indicating significance between Fall and Winter classes.

3. MANOVA across classes for Posttest raw scores yielded no significant F ratio.

4. MANOVA across classes for Pretest raw scores yielded no significant F ratio.

5. Some students experienced an increase in mathematics anxiety, and during interviews they revealed that most of the reason was due to the fact that they had never used manipulatives with mathematics before. Therefore, they were struggling with re-learning mathematics at the same time that they were learning to use the manipulatives.

TABLE 1

"SCORES FOR FALL QUARTER 1996"

n = 24

SUBJECT NUMBER	PRETEST SCORES	POSTTEST SCORES	DIFFERENCE SCORES
1	226	240	14
2	118	100	-18
3	150	133	-17
4	152	131	-21
5	253	240	-13
6	139	102	-37
7	245	166	-79
8	273	336	63
9	148	121	-27
10	120	122	2
11	252	220	-32
12	229	144	-85
13	181	133	-48
14	120	112	-8
15	175	188	13
16	239	169	-70
17	186	220	34
18	197	158	-39
19	230	250	20
20	150	186	36
21	143	199	56
22	137	130	-7
23	242	184	-58
24	178	141	-37
totals 24	4483	4125	-358
means	186.792	171.875	-14.917

TABLE 2

"SCORES FOR WINTER QUARTER 1996-1997"

n = 17

SUBJECT NUMBER	PRETEST SCORES	POSTTEST SCORES	DIFFERENCE SCORES
25	224	183	-41
26	212	188	-24
27	277	242	-35
28	275	179	-96
29	155	139	-16
30	138	107	-31
31	140	92	-48
32	202	193	-9
33	195	115	-80
34	99	100	1
35	208	174	-34
36	162	123	-39
37	169	146	-23
38	201	146	-55
39	199	100	-99
40	241	100	-141
41	354	307	-47
totals 17	3451	2634	-817
means	203	154.941	-48.059

TABLE 3

"SCORES FOR SPRING QUARTER 1997"

n = 23

SUBJECT NUMBER	PRETEST SCORES	POSTTEST SCORES	DIFFERENCE SCORES
42	124	106	-18
43	142	109	-33
44	250	295	45
45	163	169	6
46	166	152	-14
47	144	115	-29
48	128	112	-16
49	165	131	-34
50	186	138	-48
51	331	305	-26
52	205	179	-26
53	235	197	-38
54	275	208	-67
55	276	150	-126
56	156	118	-38
57	286	248	-38
58	193	174	-19
59	160	140	-20
60	148	115	-33
61	197	176	-21
62	168	104	-64
63	212	230	18
64	176	187	11
totals 2	4486	3858	-628
means	195.044	167.739	-27.304

TABLE 4

"SCORES FOR SUMMER QUARTER 1997"

n = 23

SUBJECT NUMBER	PRETEST SCORES	POSTTEST SCORES	DIFFERENCE SCORES
65	196	199	3
66	295	301	6
67	236	197	-39
68	219	208	-11
69	248	186	-62
70	191	164	-27
71	152	154	2
72	187	168	-19
73	175	159	-16
74	217	200	-17
75	140	135	-5
76	187	169	-18
77	245	150	-95
78	249	189	-60
79	237	174	-63
80	185	205	20
81	309	329	20
82	266	173	-93
83	171	142	-29
84	159	159	0
85	334	245	-89
86	257	188	-69
87	221	187	-34
totals 23	5076	4381	-695
means	220.696	190.478	-30.217

TOTAL	TOTAL	TOTAL	TOTAL
87	**17496**	**14998**	**-2498**
	MEAN	**MEAN**	**MEAN**
	201.103	**172.391**	**-28.713**

TABLE 5

"MATH ANXIETY RAW SCORE MEANS "

QUARTER	PRETEST	POSTTEST	GAIN	Valid N
Fall 96	186.7917	171.8750	-14.9167	24
Winter 96	203.0000	154.9412	-48.0588	17
Spring 97	195.0000	167.7391	-27.2609	23
Summer 97	220.6956	190.4783	-30.2174	23
All Groups	201.0919	172.3908	-28.7011	87

TABLE 6

"T-TEST COMPARISONS OF PRETEST AND POSTTEST RAW SCORES BY QUARTER "

Significance Level = $p<.05$
****Indicates significant differences.

Quarter/Year	Variables	t	df	p
Fall 96	Pretest - Posttest	1.837734	23	.0790548
Winter 96	Pretest - Posttest	5.398137	16	.0000592****
Spring 97	Pretest - Posttest	3.977876	22	.0006366****
Summer 97	Pretest - Posttest	4.118408	22	.0004518****

TABLES 7 - 9 SHOW: MANOVAS FOR DEPENDENT VARIABLES ACROSS GROUPS (QUARTERS)

TABLE 7-A

SUMMARY OF ALL EFFECTS; DESIGN 1 QUARTER MANOVA

"DEPENDENT VARIABLE: GAIN"

Significance Level = p<.05
****Indicates significance.

Effect	df Effect	MS Effect	df Error	MS Error	r	p level
1	3	3677.036	83	1312.423	2.801715	.0449112****

TABLE 7-B

POST-HOC COMPARISONS TUKEY'S HONESTLY SIGNIFICANT DIFFERENCES

"DEPENDENT VARIABLE: GAIN"

Tukey HSD test; **variable GAIN**
Probabilities for Post-Hoc Tests
Main Effect: Quarter

Significance Level = p<.05
****Indicates significance.

		(1)	(2)	(3)	(4)
QUARTER		-14.9167	-48.0588	-27.2609	-30.2174
FALL 96	**(1)**				
WINTER 96	**(2)**	.0252365****			
SPRING 97	**(3)**	.6488307	.2831756		
SUMMER 97	**(4)**	.4738863	.4187840	.9926133	

TABLE 8-A

SUMMARY OF ALL EFFECTS; DESIGN
1 QUARTER
MANOVA

"DEPENDENT VARIABLE: POSTTEST"

Significance Level = p<.05
****Indicates significance.

Effect	df Effect	MS Effect	df Error	MS Error	r	p level
1	3	4401.657	83	3023.756	1.455692	.2326310

TABLE 8-B

POST-HOC COMPARISONS
TUKEY'S HONESTLY SIGNIFICANT DIFFERENCES

"DEPENDENT VARIABLE: POSTTEST"

Tukey HSD test; **variable POSTTEST**
Probabilities for Post-Hoc Tests
Main Effect: Quarter

Significance Level = p<.05
****Indicates significance.

		(1)	(2)	(3)	(4)
QUARTER		171.8750	154.9412	167.7391	190.4783
FALL 96	**(1)**				
WINTER 96	**(2)**	.7660815			
SPRING 97	**(3)**	.9940255	.8858339		
SUMMER 97	**(4)**	.6540173	.1888638	.5015786	

TABLE 9-A

SUMMARY OF ALL EFFECTS; DESIGN
1 QUARTER
MANOVA

"DEPENDENT VARIABLE: PRETEST"

Significance Level = p<.05
****Indicates significance.

Effect	df Effect	MS Effect	df Error	MS Error	r	p level
1	3	4887.479	83	2909.143	1.680041	.1775832

TABLE 9-B

POST-HOC COMPARISONS
TUKEY'S HONESTLY SIGNIFICANT DIFFERENCES

"DEPENDENT VARIABLE: PRETEST"

Tukey HSD test; **variable PRETEST**
Probabilities for Post-Hoc Tests
Main Effect: Quarter

Significance Level = p<.05
****Indicates significance.

		(1)	(2)	(3)	(4)
QUARTER		186.7917	203.0000	195.0000	220.6956
FALL 96	**(1)**				
WINTER 96	**(2)**	.7791248			
SPRING 97	**(3)**	.9537491	.9667937		
SUMMER 97	**(4)**	.1449416	.7349563	.3756582	

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