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MARTIN, ANN ACKERMAN

THE EFFECT OF THE USE OF THE CALCULATOR ON MATHEMATICS ANXIETY IN COLLEGE ALGEBRA STUDENTS

The University of Oklahoma PH.D. 1980

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE EFFECT OF THE USE OF THE CALCULATOR ON MATHEMATICS ANXIETY IN COLLEGE ALGEBRA STUDENTS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

ANN MARTIN

Norman, Oklahoma

1980

THE EFFECT OF THE USE OF THE CALCULATOR ON

MATHEMATICS ANXIETY IN COLLEGE

ALGEBRA STUDENTS

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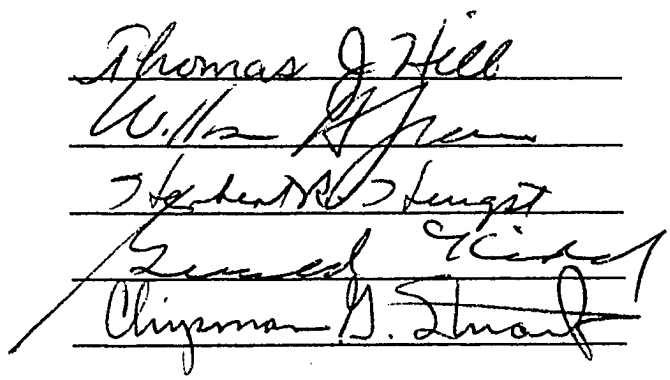

DISSERTATION COMMITTEE

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THE EFFECT OF THE USE OF THE CALCULATOR ON MATHEMATICS ANXIETY IN COLLEGE ALGEBRA STUDENTS

CHAPTER I

INTRODUCTION

Background and Rationale

Within the last few decades research has been conducted concerning the relationship between attitude toward mathematics and achievement in mathematics. Even though results are not consistent, there appears to be a low to moderate correlation between attitude and achievement (Aiken 1970; Aiken 1976). Further research indicates that attitude toward mathematics affects both electing to study mathematics and the learning of mathematics. Recognition of the relationship between attitude and achievement has led to further studies of mathematics attitude.

The idea of dimensions of attitude was studied by Fennema and Sherman in 1976. They developed mathematics attitudes scales that include nine dimensions of attitude. The scales include (a) confidence in learning mathematics; (b) father, mother, and teacher scales measuring perceptions of attitudes toward one as a learner of mathe-

matics; (c) effectance of motivation in mathematics; (d) attitude toward success in mathematics; (e) mathematics as a male domain; (f) usefulness of mathematics; and (g) mathematics anxiety scale. The Fennema-Sherman Mathematics Attitudes Scales were administered to a group of high school students and correlations between scale scores were computed. "The intercorrelations indicated that while the scales are interrelated, each scale measures a somewhat different construct" (Fennema and Sherman 1976, page 9).

One of these dimensions of attitude, mathematics anxiety, has been recognized as a problem at least since the 1950's (Gough 1954; McDermott 1956; Dreger and Aiken 1957). Mathematics anxiety has been defined as "feelings of tension and anxiety that interfere with manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson and Suinn 1972, page 551). Not only does mathematics anxiety appear to be a dimension of attitude, but it differs from general anxiety (Dreger and Aiken 1957) and occurs frequently among college students (Betz 1977; Richardson and Suinn 1972).

The reduction of mathematics anxiety is important since research indicates a relationship between this anxiety and mathematics achievement scores. A significant negative correlation between mathematics anxiety and mathematics achievement exists for college students (Dreger and Aiken 1957; Brush 1976; Betz 1977) and for high school students (Sandman 1979). Not only does it appear that mathematics anxiety reduction is related to poor mathematical performance, but it seems reasonable to assume that it is related to mathematics

avoidance. Mathematics avoidance is one symptom of mathematics anxiety (Hendel August 1977). Career choices are limited and many occupations are closed, particularly to women, because of avoidance of mathematics courses through fear of mathematics (Baylis 1979; Sells 1973).

Efforts to reduce mathematics anxiety have mushroomed during the last few years. Programs for alleviating it have been designed and implemented at several colleges and universities of which Harvard University, Wellesley College, Wesleyan University, and University of Minnesota are a few examples. Also, a New York business concern, Mind Over Math, has been formed by two mathematicians who offer counseling and consulting to mathematics anxious people. Research concerning reduction of mathematics anxiety has dealt primarily with various approaches to behavior modification, content manipulations, group counseling techniques, and bibliotherapy. Research indicates that mathematics anxiety can be reduced (Troutman 1978; Hyman 1973; McEntire and Kitchens 1979). Little has been done on the use of instructional devices, in particular the calculator, on the reduction of mathematics anxiety.

There has been research on the effects of the calculator on students' attitudes toward mathematics. The results are conflicting, but usually indicate improvement in attitude or no change in attitude. Most of the documented research has been at the elementary and secondary levels using general mathematics attitude scales. At this time there has been little research at the college level. One study conducted with college students indicated no significant differences

on a general mathematics attitude scale between a group of college algebra students using calculators and a group of college algebra students not using calculators (Cooper 1977). However, Cooper made "no attempt to determine changes in different dimensions of attitude. It is possible that using the calculator can affect some dimensions of attitude but not others...." (page 55). This raises the possibility that even though Cooper's study shows no difference in general attitude with the use of the calculator, perhaps the calculator can change a particular dimension, such as a student's level of mathematics anxiety.

Mathematics anxiety is a problem that exists, and a relationship between it and mathematics achievement has been established. Recent research indicates that mathematics anxiety can be treated. For these reasons the problem of reducing mathematics anxiety needs to be studied. The effect of the use of the calculator on mathematics anxiety in college algebra students is a needed extension of recent research.

Statement of the Problem

As mentioned above, the efforts expended toward reducing mathematics anxiety have not included the use of the calculator, and most of the calculator research has utilized general attitude scales. The research reported herein is concerned with the effect of the calculator on a student's level of mathematics anxiety. The research is directed specifically to the following questions:

1. What is the effect of the calculator on mathematics anxiety of students enrolled in a junior college course in college algebra?

2. Do the mathematics anxiety ratings of male and female students in college algebra differ?

3. Does the calculator affect the mathematics anxiety ratings of male and female students in college algebra differently?

4. Do the mathematics anxiety ratings of college algebra students enrolled in day classes differ from those of college algebra students enrolled in evening classes?

5. Does the calculator affect the mathematics anxiety ratings of day and evening college algebra students differently?

Hypotheses

In connection with the five questions posed in the statement of the problem, the present research will test the following null hypotheses:

1. There is no significant difference in mathematics anxiety between college algebra students in a junior college who use a calculator and those who do not use a calculator.

2. There is no significant difference in mathematics anxiety between male and female college algebra students.

3. There is no significant difference in the effect of the calculator on mathematics anxiety between male and female college algebra students.

4. There is no significant difference in mathematics anxiety between college algebra students enrolled in day classes and college algebra students enrolled in evening classes.

5. There is no significant difference in the effect of the calculator on mathematics anxiety between day and evening college algebra students.

CHAPTER II

REVIEW OF RELATED LITERATURE

Mathematics Anxiety

Mathematics anxiety has been recognized as a problem for the last few decades. "Number anxiety", as some researchers call it, has been found to differ from general anxiety (Dreger and Aiken 1957). Likewise, Fennema and Sherman (1976) found mathematics anxiety to be a separate dimension of mathematics attitude. They developed nine mathematics attitudes scales, each measuring a separate dimension of attitude. One of these scales is a mathematics anxiety scale. Research suggests that not only does mathematics anxiety exist, but it is a fairly common problem according to Richardson and Suinn (1972). In 1954 Gough referred to it as being as "common as a cold" (page 290). Dreger and Aiken (1957) found it present in one third of their sample of 704 college students and Crouch (1970) found it in one fifth of her sample. Betz's (1977) research indicates that mathematics anxiety occurs relatively frequently among college students in general and appears to be greater among women than men. Also, her study reveals that older students tend to have higher mathematics anxiety. Betz found that the more prior mathematics preparation a college student has had, the less likely the student is to have high mathematics

anxiety. Betz's work reveals that there is no significant difference in levels of mathematics anxiety for white and black students.

Besides Betz's research, there has been other research to discover symptoms and characteristics of the mathematically anxious person. "One symptom of mathematics anxiety is avoidance of mathematics, but continually avoiding mathematics probably leads to even higher levels of mathematics anxiety" (Hendel, August 1977, page 1). Baylis (1979) feels that career choices are closed to women because their fear of mathematics leads to mathematics avoidance. Several researchers have found a relationship between mathematics anxiety and preparation in mathematics skills (Crough 1970; Hendel, May 1977). A successful preparation correlates with reduced anxiety. Mathison's (1977) research indicates that more than a relationship exists; in fact, past mathematics education experience is a factor in producing mathematics anxiety. Similarly, Tobias (December 1978) discovered that "math avoidance is both a cause and a result of 'mathematics anxiety' ...." (page 39). A related characteristic of a "mathematics anxious" student is the student's inability to apply symbolic procedures (Doyle and Graesser 1978).

Recent research has shown a relationship between mathematics achievement and mathematics anxiety. Dreger and Aiken (1957) concluded that a person with high number anxiety tends to make lower mathematics grades. Betz (1977) revealed similar results in that she found the level of mathematics anxiety was moderately related to ACT Mathematics scores. She, also, found that lower levels of mathematics anxiety were somewhat predictive of higher mathematics course grades.

Crumpton (1977) found that an increase in mathematics competency of students is accompanied by a decrease in mathematics anxiety. Callahan and Glennon (1975) discovered similar results. Students with high scores on the Mathematics Anxiety Rating Scale earned lower grades in mathematics classes than students with low mathematics anxiety, according to Brush (1976). In his study of eighth grade and eleventh grade classes, Sandman (1979) found "a negative relationship between class mathematics anxiety and both class mathematics achievement and the perceived difficulty of the class...." (page 10). Since mathematics anxiety is a dimension of mathematics attitude, it should be noted that when attitude scores are used as predictors of achievement in mathematics, a low but significant positive correlation is usually found (Neale 1969; Aiken 1976). This is true at the elementary (Aiken 1972; Callahan and Glennon 1975), secondary (Burbank 1968; Keller 1974; Tocco 1971), and college (Whipkey 1969; Brown 1971) levels.

With recognition of mathematics anxiety as a problem related to achievement, research has been conducted to find ways to reduce it. Addleman (1972) found desensitization of the fear of mathematics led to significant gains in numerical achievement. With high school students, Hyman (1973) discovered that group desensitization effectively reduced mathematics anxiety. At the University of Minnesota, Hendel (May 1977; August 1977) integrated a diagnostic clinic, mathematics coursework, and a support group to help students with mathematics anxiety. Mathematics anxiety in the students who participated was reduced. Troutman (1978) studied female participation in a mathematics clinic and found that participation reduced anxiety toward

mathematics. Similar results were found by Auslander (1978). At Appalachian State University, McEntire and Kitchens (1979) found that a "short termed clinic" in mathematics anxiety reduction had desirable results. Parker (1979) describes results of experiments conducted with Smith on three techniques of reducing mathematics anxiety: anxiety management training, systematic desensitization, and self help bibliotherapy. All three techniques reduced mathematics anxiety. Crumpton (1977) found that increasing mathematics competence is an effective method of mathematics anxiety reduction. No research has been done testing the effect of the use of the calculator on reducing mathematics anxiety.

Calculator

Since no research is available dealing directly with the effect of the calculator on mathematics anxiety, a review of the research concerning the calculator and mathematics attitude in general is of interest. Within the last decade research on the effects of calculator usage has begun to appear in volume. In the 1977 National Council of Teachers of Mathematics Yearbook, an essay by Bell, Esty, Payne, and Suydam discusses a National Science Foundation report on the impact of the calculator. Cited as a reason to use calculators is the idea that the calculator motivates and encourages curiosity, positive attitudes, and independence. Most of the research on calculators and attitude deals with elementary and secondary students, and results are conflicting.

At the elementary level, Jones (1976) found no significant difference in attitudes between a group of sixth grade students

using calculators and a group not using calculators. Eckmier's research (1978) showed that among low achieving fourth grade students the results were the same. However, Nelson (1976) found that the attitudes of students in grades four through seven improved significantly when a calculator was used in the mathematics curriculum.

At the secondary level, several studies dealing with ninth grade general mathematics or low achieving students found no differences in attitudes between those using calculators and those not (Cech 1970; Ladd 1973; Laursen 1978). In these studies the calculator was used only for computational purposes and for checking answers. In further research of ninth grade students in a fundamentals of mathematics program, the calculator was used as an integral part of the curriculum, as well as for computation (Vaughn 1976). Again the results showed no significant difference in attitudes between calculator and noncalculator groups. In Japanese general mathematics classes, Ward (1978) found no differences in attitudes between a control group and an experimental group using calculators. Also, there was no difference in attitudes toward mathematics between males and females. In high school business arithmetic classes, Fischman (1976) discovered no significant differences in attitudes between a group of students using calculators for computation and a group not using calculators. Similar results were reported in Mastbaum's (1969) study of seventh and eighth grade slow learners.

Contrastingly, at the secondary level, Anderson (1976) in a study of junior high students found that the use of calculators improved students' attitudes toward mathematics. Also, he discovered

that if students were allowed unrestricted use of calculators in the classroom, they had greater improvement in attitude than if they were allowed to use calculators only to check answers. Advani (1972) found that twelve to fifteen year olds with learning and behavior problems had improved mathematics attitudes and increased interest in mathematics after working with calculators. In a study of ninth grade non-college bound students, Williams (1979) discovered a significant difference between groups using calculators and a group not using calculators, in attitude toward mathematics. The calculator appeared to have a positive effect on attitude. Williams had two groups using calculators, one with a regular curriculum and one with a supplemented curriculum for calculator usage. In terms of attitude, using the calculator in either curriculum was equally effective. Lastly, in a study by Longstaff, Stevens, and King (1968) mixed results were obtained on the effect of calculators with fifth and ninth graders. Results ranged from no difference in attitude to a positive effect on attitude.

Similarly, at the college level, research is conflicting. Gooden (1978) found, in a study of community college arithmetic classes, that use of the calculator as an instructional and learning aid did not result in significant changes in attitude toward mathematics. Also, Nichols (1975) discovered no difference between calculator and noncalculator groups of college basic mathematics students in attitude. Further, he found no difference in attitudes toward mathematics between males and females using calculators. However, in research conducted by Leitzel and Waits (1976) on remedial mathematics students at Ohio State University, use of calculators led to good

attitudes and good attendance. In a final study dealing with college students, Cooper (1977) found no difference in attitude between an experimental group using calculators and a control group not using them. Cooper's sample consisted of college algebra students from selected junior colleges in Oklahoma. A general mathematics attitude scale was used and no attempt was made to determine changes in different dimensions of attitude. "It is possible that using the calculator can affect some dimensions of attitude but not others...." (Cooper 1977, page 55).

The results of calculator research are conflicting, but indicate improvement in attitude or no change in attitude. The review of literature did not reveal a case in which calculator usage had a negative effect on attitude. In all of the studies, attitude was measured by a general mathematics attitude scale.

CHAPTER III

DESIGN OF THE STUDY

Sample

In order to test the five hypotheses listed in the first chapter, the regularly enrolled students of college algebra at South Oklahoma City Junior College in Oklahoma City, Oklahoma, for the 1980 spring semester, were used as the sample. This institution was selected because the mathematics department agreed to support the study and calculators were available for use in the study. There were four sections of college algebra offered; of these, two sections were taught by one instructor and the other two by another instructor. Each instructor taught one day section and one evening section. The study involved a control group, consisting of a day section taught by one instructor and an evening section taught by the other instructor. Also involved was an experimental group consisting of a day section, taught by the instructor of the evening section in the control group, and an evening section, taught by the instructor of the day section in the control group. The initial selection of a college algebra section to be included as part of the experimental group was randomly made. The other sections were then placed into either the control group or the experimental group, according to the above conditions. The experi-

mental group used calculators during the study, and the control group did not. At the time of enrollment, students were not told which sections would use calculators and which would not. International students enrolled in college algebra were eliminated from the study to avoid contamination of the results by reading problems.

The control group consisted of fifty-three students at the onset of the experiment. Of these twenty-seven were males and twenty-six females. The day section had twenty-four students and the evening section had twenty-nine. The day section met from 11:00-11:55 a.m. on Monday, Wednesday, and Friday; while the evening section met from 5:30-8:00 p.m. on Tuesday. The experimental group consisted of fifty students. There were twenty-seven males and twenty-three females. The day section, which was held from 8:00-9:25 a.m. on Tuesday and Thursday, had twenty-seven students. The night section, which met on Wednesday from 5:30-8:00 p.m., had twenty-three students. The total number of students involved at the beginning of the study was 103, with fifty-four being males and forty-nine being females, and with fifty-one day students and fifty-two evening students.

The treatment lasted the first seven weeks of the semester. At the end of the seven weeks, the total number of students involved was sixty-three. (This attrition rate experienced was average for this subject at this college.) Of these sixty-three students, thirty-one were in the control group and thirty-two were in the experimental group. The day sections had thirty-seven students and the night sections had twenty-six. Male students numbered thirty-one, while females numbered thirty-two.

Procedure

The study began with the first class meeting of the spring semester 1980 at South Oklahoma City Junior College and continued for seven weeks. The content material taught was the same for the control group and the experimental group, and it was the regular curriculum used the previous semester at the college. Detailed lesson plans were made in advance for both groups to follow. The groups were kept at the same pace and covered the same material and examples. The only difference in the classroom activity was in calculator use; the experimental group had unrestricted use of calculators and the control group was not allowed to use calculators. In the experimental group, the calculator was used as a learning tool in the presentation of material, as well as for computation. For example, when discussing the definition of exponents $a^0 = 1$ when $a \neq 0$, students were instructed to use their calculators to find $7^{\cdot 1}$, $7^{\cdot 001}$, and $7^{\cdot 000001}$. This exercise helped give meaning to the definition. When this example was presented in the control classes, the instructors presented the students the figures: $7^{\cdot 1} = 1.215$, $7^{\cdot 001} = 1.002$, and $7^{\cdot 000001} = 1.0000019$. Appendix A contains an outline of other selected examples from the lesson plans.

On the first class day the students completed the Suinn's Mathematics Anxiety Rating Scale. Those in the experimental group were asked to bring calculators to class and a survey was conducted to determine the number of students who did not have one. The instructor provided calculators for in-class use to those students without one. During each class period, each student and the instructor in the experimental group had a calculator. The students used their own

calculators, or one provided by the instructor. Instruction on how to use the calculator was given on an individual basis, if a student needed assistance. The control group, including the instructors, was not permitted to use calculators in class.

During the seven weeks that the experiment was in progress, three observers were asked to make unannounced visits to each of the college algebra sections. One of the observers was a mathematics laboratory supervisor at the college and another was the assistant supervisor. The other observer was an adjunct professor at the college. The observers were asked to note if and how calculators were used. Two of the observers made eight visits, two to each of the four sections involved, and the other observer made seven visits. A copy of the form completed at the time of each observation is included in Appendix B.

At the conclusion of seven weeks of classes, the Mathematics Anxiety Rating Scale was readministered to both the control and experimental groups. Also, a survey form was completed by the students that gave information about their out-of-class use of calculators. A copy of the survey form is in Appendix B.

Instrument

The Mathematics Anxiety Rating Scale (MARS) by Richard M. Suinn (1972) was used in this study. The MARS is a "98-item scale composed of descriptions of situations that might arouse different levels of mathematics anxiety" (Suinn, Edie, Nicoletti, and Spinelli 1972, page 373). Selected items from the MARS are in Appendix B. On

the MARS, a subject decides which level of anxiety is associated with each scale item ranging from 1 "Not at all" to 5 "Very much". The MARS is intended to be a research scale and was originally standardized on a university sample. The test-retest reliability after a seven-week period was .85, while the internal consistency reliability was .97 (Suinn 1972). Correlation between MARS scores and scores on the numbers portion of the Differential Aptitude Test (DAT) have been found to range from -.32 to -.64. Since high mathematics anxiety should be associated with lower performance on mathematics tests, these negative correlations suggest that the MARS measures mathematics anxiety (Suinn 1972). The mean score for a sample of 397 university students was 215.38 with a standard deviation of 65.29 (Richardson and Suinn 1972). In another sample of 119 university students, the mean score was 187.3 with a standard deviation of 55.5 (Suinn, Edie, Nicoletti, and Spinelli 1972).

Data Analysis

With reference to the statement of hypotheses at the end of Chapter I, the null hypotheses 1, 3, and 5 were tested by deriving the difference between pretest score on the MARS and post-test score for each student in both groups. Only those students who completed both the pretest and the post-test were used. A three-way analysis of variance was the statistical procedure used to compare the difference scores between calculator and noncalculator groups, males and females, and day and evening students. Hypothesis 1 was tested by utilizing one of the main effects in the analysis of variance. The .05 level was selected as the minimal level at which significance would be

reported for the F value obtained. To test whether the calculator affected males and females differently, one of the interaction effects of the analysis of variance was used. Another interaction effect was studied to determine whether the calculator had a different effect on day and evening students. Both of these hypotheses were tested at the .05 level.

Null hypotheses 2 and 4 were tested using pretest scores. Two of the main effects were used to determine if there was a difference in mathematics anxiety between males and females or between day and evening students. The third main effect, comparing pretests of the control and experimental groups, was used to test whether the two groups were significantly different at the onset of the study. Again the .05 level was used for testing significance in this analysis of variance.

Finally, to determine if the mathematics anxiety rating of the experimental group changed significantly from the beginning of the study to the end, a t test was made using the difference in pretest and post-test scores. The following formula for t was used:

$$t = \frac{\bar{x}}{s_x/\sqrt{n}}$$

The t value was evaluated using n - 1 degrees of freedom. Similarly, another t test was made using data from the control group.

CHAPTER IV

FINDINGS OF THE STUDY

Results Concerning the Mathematics Anxiety of the Original Sample

The Mathematics Anxiety Rating Scale (MARS) was hand scored by the experimenter. A high score indicated a high level of mathematics anxiety. The possible range of scores is 98 to 490. For the 103 students given the pretest MARS, the mean was 184.83. The mean score for the control group was 180.19 with a standard deviation of 43.03; for the experimental group, the mean was 189.74 with standard deviation of 57.32. The males had a mean rating of 190.93 with standard deviation of 57.88, and the females had 178.10 with 46.05 standard deviation. For the day students, the mean was 169.82 with standard deviation 45.25. However, for the evening students, the mean was 199.54 and standard deviation was 55.74. Table I has further normative data. Raw scores are in Appendix C.

The two hypotheses concerning mathematics anxiety of the original sample are:

2. There is no significant difference in mathematics anxiety between male and female college algebra students.

4. There is no significant difference in mathematics anxiety between college algebra students enrolled in day classes and

college algebra students enrolled in evening classes.

TABLE I

NORMATIVE DATA FOR ORIGINAL SAMPLE

A. Control Group

	Male	Female
Day	$\underline{n} = 14$ $\overline{X} = 172.14$	$\underline{n} = 10$ $\overline{X} = 163.30$
Evening	$\underline{n} = 13$ $\overline{X} = 205.85$	$\underline{n} = 16$ $\overline{X} = 176.94$

B. Experimental Group

	Male	Female
Day	$\underline{n} = 14$ $\overline{X} = 167.36$	$\underline{n} = 13$ $\overline{X} = 175.00$
Evening	$\underline{n} = 13$ $\overline{X} = 221.62$	$\underline{n} = 10$ $\overline{X} = 198.80$

A difference in means between control and experimental, male and female, and day and evening students exists. To determine whether these differences were significant, a three-way analysis of variance was used. The pretest MARS scores were analyzed with regard to group (control and experimental), gender (male or female), and time of class (day or evening). The results are found in Table II.

TABLE II

ANALYSIS OF VARIANCE FOR THE ORIGINAL SAMPLE

Source	DF	Mean Square	F	Sign. of F
Group	1	3590.974	1.393	0.241
Gender	1	5023.156	1.949	0.166
Time of Class	1	25194.359	9.775	0.002
Time of Class and Gender	1	3977.551	1.543	0.217
Time of Class and Group	1	1558.496	0.605	0.439
Gender and Group	1	797.483	0.309	0.579
Time of Class, Gender, and Group	1	169.785	0.066	0.798
Residual	95	2577.535		
Total	102	2780.063		

Study of Table II shows one significant F score at the .05 level and that is time of class. These results indicate that the null Hypothesis 4 should be rejected. However, the difference in mathematics anxiety between males and females is not significant and the null Hypothesis 2 should not be rejected. Finally, the results of the three-way analysis of variance indicate that there is no significant difference in mathematics anxiety between the control and the experimental groups.

Results Concerning the Effects of the Calculator

When the MARS was readministered following the experiment, the difference between the two MARS scores was found for each student (Pre-test minus Post-Test). The raw data obtained is in Appendix C. Sixty-three students were involved in the final sample. The mean of the differences in pretest and post-test was 14.44. A positive difference indicates a lower mathematics anxiety rating on the post-test than on the pretest. For the control group, the mean of the differences was 7.23 with a standard deviation of 30.83 and a correlation between pre-test and post-test of 0.87. The mean of the differences of the experimental group was 21.44 with a standard deviation of 32.39 and a correlation of 0.71. The males had a mean of the differences of 10.48; while this difference was 18.28 for females. The mean of the differences for the day students was 17.05 and for the evening students it was 10.73. Table III has further normative data on the differences.

TABLE III

NORMATIVE DATA ON THE DIFFERENCES
BETWEEN PRETEST AND
POST-TEST SCORES

A. Control Group

	Male	Female
Day	$\underline{n} = 11$ $\overline{X} = 8.09$	$\underline{n} = 6$ $\overline{X} = 23.50$
Evening	$\underline{n} = 7$ $\overline{X} = -10.57$	$\underline{n} = 7$ $\overline{X} = 9.71$

B. Experimental Group

	Male	Female
Day	$\underline{n} = 9$ $\overline{X} = 30.22$	$\underline{n} = 11$ $\overline{X} = 11.73$
Evening	$\underline{n} = 4$ $\overline{X} = 9.50$	$\underline{n} = 8$ $\overline{X} = 30.88$

The three null hypotheses concerning the effects of the calculator on mathematics anxiety are:

1. There is no significant difference in mathematics anxiety between college algebra students in a junior college who use a calculator and those who do not use a calculator.

3. There is no significant difference in the effect of the calculator on mathematics anxiety between male and female college algebra students.

5. There is no significant difference in the effect of the calculator on mathematics anxiety between day and evening college algebra students.

Since differences in means existed between the various categories, a three-way analysis of variance was used to determine if the differences were significant. The differences between pretest and post-test scores were analyzed with regard to group (control or experimental), gender (male or female), and time of class (day or evening). The results are in Table IV.

Study of Table IV shows no significant F scores at the .05 level. Therefore, Hypotheses 1, 3, and 5 cannot be rejected. However,

as noted earlier, there appeared to be a distinction between the mean of differences in pretests and post-tests for the control group (7.23) and for the experimental group (21.44). To further analyze these two groups, a t test was used.

TABLE IV

ANALYSIS OF VARIANCE FOR DIFFERENCES BETWEEN PRETEST AND POST-TEST SCORES

Source	DF	Mean Square	F	Sign. of F
Group	1	2419.277	2.456	0.123
Gender	1	591.948	0.601	0.441
Time of Class	1	547.999	0.556	0.459
Time of Class and Gender	1	1705.608	1.732	0.194
Time of Class and Group	1	978.328	0.993	0.323
Gender and Group	1	1409.841	1.432	0.237
Time of Class, Gender, and Group	1	1093.030	1.110	0.297
Residual	55	984.855		
Total	62	1035.797		

Using the formula referred to at the end of Chapter III, a t value of 1.3405 was obtained for the control group. With thirty degrees of freedom, this t was not significant at the .05 level. Repeating the process for the experimental group yielded a t score of 3.7445, and

with thirty-one degrees of freedoms, this t was significant at the .01 level. These results imply that significant change occurred within the experimental group, but not within the control group. However, when the changes of the two groups were compared in the analysis of variance, there was not a significant difference between them.

Results of Survey and Observations

At the conclusion of the study, a survey to gain information about the student's out-of-class use of the calculator was given. The results indicated that fourteen students in the experimental group had limited experience with calculators before the beginning of the study, while eighteen had extensive experience. During the study, thirteen students had limited experience with calculators outside of class, eighteen had extensive experience, and one never used it. In the control group, twenty students had limited experience with calculators before the onset of the study and eleven had extensive experience. However, during the study, eighteen never used a calculator outside of class and thirteen did only sometimes.

On the unannounced visits made by the three observers, results indicated that the study was performed as described in Chapter III. The observers were in agreement that, in each class meeting of the experimental group, each student and the instructor had a calculator. Calculators were used in the formation of concepts, for computation, and during tests. Instructor's bias toward calculators was not evident during class. In the control group, calculators were not present in the classroom and no mention was made of them. Again, no instructor's bias toward calculators was evident.

CHAPTER V

CONCLUSION

Summary of the Study

Mathematics anxiety is an irrational fear of numbers and mathematical situations. Within the last few decades, research has shown that mathematics anxiety does exist and that it is a common problem among college students. Also, research has shown that mathematics achievement and mathematics anxiety are related. Low anxiety has a positive correlation with good course grades and good achievement test scores. Efforts have been made to reduce mathematics anxiety in students. A review of the research in this area indicates that mathematics anxiety can be reduced.

Another current topic of research is the calculator. Studies report conflicting results on the effect of the calculator on attitude toward mathematics. The calculator is reported to have either no effect on attitude or a positive effect on attitude. One possible explanation is that the calculator affects only certain dimensions of attitude, such as mathematics anxiety. The purpose of this study was to investigate the effect of the calculator on the mathematics anxiety of college algebra students.

In order to investigate this effect, the college algebra classes at South Oklahoma City Junior College during the spring semester, 1980, were separated into a control group and an experimental group. The experimental group used calculators in class for concept formation and for computation. The control group did not use calculators in class. Both groups completed the Mathematics Anxiety Rating Scale (MARS) at the beginning of the semester and at the end of the seven week experimental period.

Two analysis of variance statistics were computed, using the pretest scores and using the differences in pretest and post-test scores, to test the following hypotheses:

1. There is no significant difference in mathematics anxiety between college algebra students in a junior college who use a calculator and those who do not use a calculator.

2. There is no significant difference in mathematics anxiety between male and female college algebra students.

3. There is no significant difference in the effect of the calculator on mathematics anxiety between male and female college algebra students.

4. There is no significant difference in mathematics anxiety between college algebra students enrolled in day classes and college algebra students enrolled in evening classes.

5. There is no significant difference in the effect of the calculator on mathematics anxiety between day and evening college algebra students.

At the .05 level of significance only one hypothesis was rejected--Hypothesis 4.

Inferences

The results of this study show that the null hypothesis, that there is no significant difference between day and evening college algebra students in mathematics anxiety, should be rejected. Furthermore, the mean score for the evening students in this study was higher than the mean score for the day students. This research indicates that students enrolled in evening classes of college algebra have higher mathematics anxiety levels than students enrolled in day classes.

From the lack of rejection of the hypothesis that there is no difference between college algebra students using calculators and those not using calculators in mathematics anxiety, this study suggests that the calculator alone does not affect mathematics anxiety in college algebra students. However, the combination of the calculator, the college algebra course itself, and other in-class and out-of-class activities does reduce mathematics anxiety. These conclusions follow from the fact that the calculator group experienced a significant reduction in mathematics anxiety during the experiment. The non-calculator group had a nonsignificant reduction in mathematics anxiety. When the two groups' reductions were compared to each other by the analysis of variance, no significant difference was found between the two reductions.

The other null hypotheses were not rejected. For this sample of college algebra students, the mean mathematics anxiety level was higher for males than females, but not significantly higher. The

hypothesis, that there is no difference between males and females in mathematics anxiety, was not rejected. This study suggests that the mathematics anxiety levels of male and female college algebra students in this sample do not differ. From the interaction effects of the three way analysis of variance, the hypotheses concerned with the effects of the calculator on mathematics anxiety were not rejected. Using this group of college algebra students from South Oklahoma City Junior College, this study suggests that there is no difference between male and female students in the effect of the calculator on mathematics anxiety. Furthermore, this study suggests that for this sample there is no difference between the day and the evening college algebra students in the effect of the calculator on mathematics anxiety.

Recommendations

This study indicated that evening college algebra students had higher levels of mathematics anxiety than day college algebra students. Even though the calculator did not affect the two groups differently, perhaps some other learning aid or treatment will. Further research in this area, and with the evening student in general, needs to be conducted.

Unfortunately, the original sample (103 students) in the study was reduced to sixty-three students at the time of the retesting. While the raw scores in Appendix C indicate that the mathematics anxiety levels for the students not completing the experiment ranged from high (317) to low (102), the study would have been more representative of all college algebra students if the attrition rate had been lower. It should also be noted that more evening students did

not complete the study than day students. Replication of the research at an institution with better completion rates, or replication of the study using a different time frame, might produce different results.

College algebra is usually considered a freshman entry-level, college mathematics course. However, many junior colleges, and some four-year colleges and universities, offer developmental mathematics courses for students without the prerequisites for college algebra. Since a relationship exists between mathematics anxiety and preparation in mathematics skills, perhaps the effect of the calculator on the mathematics anxiety of developmental mathematics students should be investigated.

The mean mathematics anxiety level for males in this study was higher than that for females, but not significantly higher. In research conducted by Betz (1977), mathematics anxiety appeared to be greater among women than men. The results of Betz's study and this study appear to conflict. Further research on the existence of mathematics anxiety in male and female students is needed to clear the issue.

The problem of reducing mathematics anxiety in students needs further attention. Methods to alleviate anxiety need to be discovered. Many of the techniques discussed in the literature require the use of out-of-class time and the aid of counselors. Without minimizing these techniques, the need still exists for methods to be used in the classroom by the instructor. This study of the effect of the calculator is one attempt in this direction.

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APPENDIX A

LESSON PLANS

Outline of Selected Examples from the Lesson Plan for College Algebra

I. Properties of Exponents

A. Justify $a^0 = 1 \quad (a \neq 0)$

Illustrate with $7^{.1} = 1.215$, $7^{.001} = 1.002$, $7^{.000001} = 1.00000019$

Experimental Group: Actually derive these figures

Control Group: Will be given the above figures

B. Explain $a^m \cdot a^n = a^{m+n}$

Illustrate with $9^3 \cdot 9^5 = 9^8$, $9^3 \cdot 9^5 \neq 9^{15}$

Experimental Group: Use calculator to find $9^3 \cdot 9^5$ and 9^8

Control Group: $9^3 \cdot 9^5 = (9 \cdot 9 \cdot 9) \cdot (9 \cdot 9 \cdot 9 \cdot 9 \cdot 9) = 9^8$ Use property

C. Explain $\frac{a^m}{a^n} = a^{m-n}$; $(a^m)^n = a^{mn}$

Illustrate $\frac{5^8}{5^2} = 5^6$; $(7^3)^4 = 7^{12}$

Experimental and control groups activities similar to (B)

II. Polynomials (addition)

$(2x^2 + x - 1) + (x^2 - 3x + 4) = 3x^2 - 2x + 3$ Evaluate for $x = 3$

Experimental Group: Use calculator to show expressions are equivalent

Control Group: Use paper and pencil to evaluate

III. Algebraic Fractions

Discussion of $\frac{5}{x - 2}$ and why $x \neq 2$ Evaluate for $x = 1.99$, $x = 1.9999$, $x = 2.01$, $x = 2.0001$

Experimental Group: Use calculator to actually substitute values of x into expression

Control Group: Given the facts that $\frac{5}{1.99 - 2} = -500$,

$\frac{5}{1.9999 - 2} = -50{,}000$ $\frac{5}{2.01 - 2} = 500$

$\frac{5}{2.0001 - 2} = 50{,}000$

IV. Radicals

Illustrate $\sqrt{8} = \sqrt{4}\sqrt{2} = 2\sqrt{2}$

Experimental Group: Use calculator to substantiate each step

Control Group: Use properties of radicals to explain

V. Radical Equations

Example: $x - 5 = \sqrt{x - 3}$

Experimental Group: Use calculator to check answers and to show why x = 4 is not a solution.

Control Group: Use paper and pencil to check

APPENDIX B

FORMS USED IN THE STUDY

Observer: _____

Date of Observation: _____

Time of Observation: _____

OBSERVATION

	YES	NO
1. A calculator was used by the instructor.		
2. Calculators were used by the students.		
3. The instructor showed a bias either for or against the calculator.		
If the answer to either (1) or (2) was yes, then answer the following:		
4. Each student had access to a calculator.		
5. The calculator was used for computation.		
6. The calculator was used in the formation of concepts.		

COMMENTS:

College Algebra Survey

February 1980

Name _____

Time and Day of Class _____

1. Had you used a calculator before the beginning of this course (at work, school, home, etc.)?

never	some	a great deal

2. Do you use a calculator outside of class when you study college algebra?

never	some	most of the time

Name _____ Total Score _____

MATHEMATICS ANXIETY RATING SCALE (MARS)

The items in the questionnaire refer to things and experiences that may cause fear or apprehension. For each item, place a check (✓) in the box under the column that describes how much you are frightened by it nowadays. Work quickly, but be sure to consider each item individually.

	Not At All	A Little	A Fair Amount	Much	Very Much
2. Having someone watch you as you total up a column of figures.					
25. Watching a teacher work an algebraic equation on the blackboard.					
26. Signing up for a math course.					
48. Figuring the sales tax on a purchase that costs more than $1.00.					
49. Having a person illustrate to you the best way to divide your money into a savings and a checking account.					
80. Walking to math class.					

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APPENDIX C

RAW DATA

TABLE V

RAW SCORES FOR THE CONTROL GROUP

Student	Pretest	Post-Test	Difference	Gender	Time of Class
1	239	247	-8	Male	Evening
2	248	318	-70	Male	Evening
3	161	122	39	Male	Evening
4	161	165	-4	Male	Evening
5	302	335	-33	Male	Evening
6	222	244	-22	Male	Evening
7	223	199	24	Male	Evening
8	141	118	23	Female	Evening
9	174	160	14	Female	Evening
10	244	243	1	Female	Evening
11	157	140	17	Female	Evening
12	127	145	-18	Female	Evening
13	141	127	14	Female	Evening
14	206	189	17	Female	Evening
15	178	185	-7	Male	Day
16	116	99	17	Male	Day
17	197	146	51	Male	Day
18	142	114	38	Male	Day
19	127	124	3	Male	Day
20	212	253	-41	Male	Day
21	146	120	26	Male	Day
22	129	109	20	Male	Day
23	211	182	29	Male	Day
24	192	233	-41	Male	Day
25	190	186	4	Male	Day
26	130	122	8	Female	Day
27	197	197	0	Female	Day
28	187	165	22	Female	Day
29	158	173	-15	Female	Day
30	175	143	32	Female	Day
31	229	135	94	Female	Day

TABLE VI

RAW SCORES FOR THE EXPERIMENTAL GROUP

Student	Pretest	Post-Test	Difference	Gender	Time of Class
1	222	217	5	Male	Evening
2	207	194	13	Male	Evening
3	166	148	18	Male	Evening
4	124	122	2	Male	Evening
5	146	134	12	Female	Evening
6	217	144	73	Female	Evening
7	185	157	28	Female	Evening
8	248	194	54	Female	Evening
9	178	168	10	Female	Evening
10	155	152	3	Female	Evening
11	135	101	34	Female	Evening
12	215	182	33	Female	Evening
13	181	173	8	Male	Day
14	176	140	36	Male	Day
15	201	106	95	Male	Day
16	234	126	108	Male	Day
17	146	137	9	Male	Day
18	148	159	-11	Male	Day
19	191	136	55	Male	Day
20	137	158	-21	Male	Day
21	150	157	-7	Male	Day
22	208	188	20	Female	Day
23	180	174	6	Female	Day
24	320	259	61	Female	Day
25	107	104	3	Female	Day
26	134	139	-5	Female	Day
27	214	181	33	Female	Day
28	157	207	-50	Female	Day
29	253	252	1	Female	Day
30	168	131	37	Female	Day
31	150	138	12	Female	Day
32	137	126	11	Female	Day

TABLE VII

ADDITIONAL RAW SCORES ON THE ORIGINAL SAMPLE ONLY

Student	Group	Pretest	Gender	Time of Class
64	Control	121	Male	Evening
65	Control	121	Male	Evening
66	Control	226	Male	Evening
67	Control	188	Male	Evening
68	Control	317	Male	Evening
69	Control	147	Male	Evening
70	Control	177	Female	Evening
71	Control	144	Female	Evening
72	Control	160	Female	Evening
73	Control	233	Female	Evening
74	Control	225	Female	Evening
75	Control	168	Female	Evening
76	Control	179	Female	Evening
77	Control	142	Female	Evening
78	Control	213	Female	Evening
79	Control	192	Male	Day
80	Control	103	Male	Day
81	Control	275	Male	Day
82	Control	169	Female	Day
83	Control	140	Female	Day
84	Control	127	Female	Day
85	Control	121	Female	Day
86	Experimental	211	Male	Evening
87	Experimental	304	Male	Evening
88	Experimental	169	Male	Evening
89	Experimental	127	Male	Evening
90	Experimental	243	Male	Evening
91	Experimental	222	Male	Evening
92	Experimental	348	Male	Evening
93	Experimental	312	Male	Evening
94	Experimental	226	Male	Evening
95	Experimental	275	Female	Evening
96	Experimental	234	Female	Evening
97	Experimental	149	Male	Day
98	Experimental	224	Male	Day
99	Experimental	138	Male	Day
100	Experimental	166	Male	Day
101	Experimental	102	Male	Day
102	Experimental	105	Female	Day
103	Experimental	142	Female	Day