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THE ASSOCIATION BETWEEN TESTING STRATEGIES
AND PERFORMANCE IN COLLEGE ALGEBRA,
ATTITUDE TOWARDS MATHEMATICS,
AND ATTRITION RATE

DISSERTATION

Presented to the Graduate Council of the
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By

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The purposes of the study were: (1) to determine the effects of four testing strategies upon performance in college algebra, attitude towards mathematics, and attrition rate; (2) to determine the effects of two types of frequent testing upon performance, attitude, and attrition rate; (3) to determine the effects of different frequencies of in-class testing upon performance, attitude, and attrition rate; and (4) to draw conclusions which might help in selecting testing methods for college algebra classes. The sample to test the hypothesis regarding attrition rate consisted of 168 students. Of the 168 students, 118 took a final examination and comprised the sample to test the hypothesis regarding performance in college algebra and attitude towards mathematics. The subjects were distributed among four intact Math 121 college algebra classes taught at Louisiana State University in Shreveport in the fall of 1986. The instruments used were the Aiken-Dreger Revised Math Attitude Scale and the Cooperative Mathematics Tests: Arithmetic, Algebra II, and Algebra III. Analysis of covariance and a test for the significance of differences

in proportions from four independent groups were used to test the hypotheses of the study. It was found that classes administered required homework, several short weekly quizzes, regular chapter tests, or just a midsemester and final examination were not significantly different at the .05 level in adjusted mean performance on a final examination. These classes did not differ in adjusted mean posttest attitude towards mathematics, but they were significantly different in attrition rate. When only comparing the in-class testing strategies (Homework class omitted), the classes differed significantly in adjusted mean posttest attitude with the Quiz class having the most positive attitude. The Homework and Test class were the only pair to differ significantly in attrition rate with a student in the Test class three times as likely to drop out. Required homework appears to improve retention in a college algebra class.

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CHAPTER I

INTRODUCTION

Teaching college algebra usually involves the lecture-problem-solving method of instruction. Students spend most of their time working on problems related to material covered in class and read from a textbook. A major concern involved in this teaching process is the plan, method, or system incorporated to test and present feedback to the students.

Various testing strategies have been used ranging from only giving a midterm and final examination to including several chapter tests or collecting and grading daily homework, or just giving weekly quizzes (10, 30). The diversity of possible testing strategies in college algebra courses seems to justify additional research to detect any significant differences in the interpretation of these testing strategies.

Gaynor and Millham (10) as well as Semb (23), Williams and Lawrence (31), and Dustin (8) found that students who were given weekly tests scored significantly higher on a final examination than did those who only had a midterm examination. A study done by Born (4) found no differences on final examination scores for students tested frequently

when compared to less frequent testing. A research investigation conducted by Matthes (17) revealed no significant differences in performance or attitude of students who had required homework when compared with those who did voluntary homework only.

This study provides information to allow students to be efficiently tested in college algebra, and contributes to existing knowledge about causes of high attrition among college algebra students. It also indicates to college teachers of algebra whether they need to change their established testing and feedback strategies (5, p. 12). Extending the research done on frequency of testing into the larger framework of comparing testing strategies by using performance, attitude, and attrition measures benefits both student and teacher.

Statement of the Problem

The problem of this study was the association between testing strategies and performance in college algebra, attitude towards mathematics, and attrition rate.

Purposes of the Study

The purposes of this study were

1. to determine the effects of four testing strategies upon performance in college algebra, attitude towards mathematics, and attrition rate;
2. to determine the effects of two types of frequent

testing upon performance in college algebra, attitude towards mathematics, and attrition rate;

3. to determine the effects of different frequencies of in-class testing upon performance in college algebra, attitude towards mathematics, and attrition rate; and

4. to draw conclusions which might serve as a basis for selecting testing methods for college algebra classes.

Hypotheses

To carry out the purposes of the study, the following null hypotheses were tested.

1. There is no significant relationship between the pretest variables:

- (a) algebra achievement,
- (b) attitude towards mathematics, and
- (c) arithmetic achievement,

and each of the criterion variables: performance in college algebra, posttest attitude towards mathematics, and attrition rate;

2. There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

3. There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

between the two classes using different types of frequent testing: Quiz class and Homework class; and

4. There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

among the groups which are tested in-class with different frequencies: Quiz class, Test class, and Control class.

Background

A recent report from the Study Group on the Conditions of Excellence in American Higher Education (20) contended that the quality of American higher education could be significantly improved by applying existing knowledge about three critical conditions of excellence: (a) student involvement, (b) high expectations, and (c) assessment and feedback. Integrating these conditions into colleges and universities ultimately means that teachers may have to change their teaching methods or, at least, modify how they conduct the classroom educational process.

In the discipline of mathematics, college teachers have traditionally used the lecture-problem-solving method in their classrooms. The process by which teachers control

student involvement, objectives, goals, and feedback to their students should be a carefully planned part of teacher-student interaction. Classroom plans range from daily problem assignments in conjunction with several unit examinations to no homework with only midsemester and final examinations administered. Students may not be sufficiently involved with "time on task" and may not be receiving the proper "knowledge of results" to insure an opportunity to learn the course content. This was an investigation of this problem in terms of the relationship of testing strategies to final examination scores in college algebra, attitudes of students towards mathematics, and dropout rates.

Theoretical Frame of Reference

Several learning theories appear to be related to the hypotheses of this study: E. L. Thorndike's reinforcement theory, C. L. Hull's drive theory, and Kurt Lewin's field theory. Thorndike's connectionist theory, "the law of exercise", in its revised form (26, 27, 28) was used as a model to investigate whether frequent short tests or required homework assignments in a college algebra class are preferred over longer less frequent tests.

When Thorndike first proposed the law of exercise, he suggested that the connection or association between a stimulus and a response is strengthened by repetition alone. After continued studies he shifted his views. The

emphasis in his theory changed from repetition to such factors as distribution of practice, knowledge of results, incentives, and whole learning versus part learning (14).

The concept of distribution of practice: repetition with rest periods combined with feedback, gives the learner a chance to correct errors and to profit by his experiences. Application of this theory means that frequent testing or required homework with their natural feedback for the student should lead to a significantly higher performance on a final examination in college algebra than either infrequent, long examinations or no exams.

Distribution of practice as a theoretical construct can be explained by several concepts such as: perseveration, fatigue, motivation, rehearsal, maturation, reactive inhibition, and differential forgetting (14). Available evidence (2, 9, 13, 14, 18) supports reactive inhibition, differential forgetting, and to a lesser extent motivation as the primary explanations for the superiority of distribution of practice as a learning theory.

Reactive inhibition is a theoretical construct of Hull (12). It is a term used to describe the tendency to avoid repetition of a response once given. Reactive inhibition is believed to decrease directly as the amount of time allowed for rest; this process would account for the improved performance observed in distributed practice when compared to massed practice. Studies by Ammons (2) and

Kimble (13) showed a high buildup of reactive inhibition early in practice or in highly motivated groups; a marked increase in performance occurred when regular rest periods were inserted between practice sessions.

Easley (9) and McGeoch (18) discussed the advantages of distribution of practice via differential forgetting: we learn wrong responses as well as right responses during practice, but the right ones are more often repeated; thus the wrong responses are not learned as well and are forgotten more rapidly during the intervals of no practice. The rest periods between practice sessions make possible the progressive elimination of incorrect responses.

This research tends to indicate that increased motivation and decreased reactive inhibition and differential forgetting during rest periods work together to facilitate performance and possibly even learning. Kingsley and Garry said that the experiments dealing with distribution of practice appear to show

. . . that when the amount of work involved in a task is great, when the task is complex or not particularly meaningful, when the frequency of error responses is likely to be high, or when motivation is low or amount of effort required high, the practice sessions should be spaced with primary attention devoted to the length of the practice period rather than of the rest period (14, pp. 249-250).

One of the subsidiary laws of Thorndike's connectionism applicable to human learning is Set or Attitude (25). This is the second of five subordinate laws

used to discuss principles which Thorndike thought to be somewhat less important than the major laws of readiness, exercise, and effect. The total attitude or "set" of an organism guides its learning. Attitude determines what will annoy or satisfy a person as well as what he will do. For example, a more ambitious student will be annoyed by results which the average, uninspired student would cherish. The hypotheses related to attitude will be checked with this theory as a guide.

A college algebra student appears to perceive "in-class" examinations (quizzes or tests) as tension-producing. Hometests or homework assignments, while required, probably produce less tension than in-class tests. A major premise of this study is that repeated in-class quizzes, short in length, will produce more internal tension than required homework. The student will strive to relieve this tension with extra effort which should lead to a significantly higher performance on the final examination as well as a significantly higher posttest attitude score. The theoretical framework used to model this premise will be Kurt Lewin's field theory (6, 15). This study checked the proposition that higher tension in a student's life space produces more internal motivation to reduce that tension.

Significance of the Study

This study was concerned with the association between testing strategies and the outcomes in college algebra classes relative to performance, attitude change, and attrition rate. The focus was on the effects of frequent testing and homework upon posttest attitude toward mathematics and performance in college algebra.

This study was significant in that it

1. Added to the body of knowledge related to comparisons between frequent testing and homework upon performance in college algebra, attitude towards mathematics, and attrition rate (17, 22, 32);
2. Can be used by college mathematics professors to make more intelligent choices of testing strategies from traditional possibilities (10, 19, 30);
3. Explored the relationship between algebraic achievement, arithmetic achievement, attitude towards mathematics and testing strategies. (1, 3, 7, 21, 29); and
4. Added to available literature related to such educational learning theories as Thorndike's law of exercise and distribution of practice, Hull's reactive inhibition, and Lewin's study of tension systems (9, 10, 13, 16, 17, 18, 23, 24).

Definition of Terms

The following terms were defined for the purposes of this study:

Homework assignment.--Selected problems from the end of a section of new material in a college algebra textbook to be completed and turned in for grading and feedback.

Minimum testing.--Total tests given during one semester consisting of a midsemester examination and a cumulative final examination.

Math 121 class.--A college algebra class taught at Louisiana State University in Shreveport. An ACT (American College Test) score above 16 and credit for two years of high school algebra are the normal requirements for placement in this course at registration. Any student may be placed in Math 121 with permission.

Intact group(class).--A college algebra class formed during regular registration procedures at Louisiana State University in Shreveport.

Quiz class.--A college algebra class which is tested by two 10 to 15 minute tests per week each covering the material from the previous class.

Homework class.--A college algebra class which is tested by turning in two required homework assignments per week.

Test class.--A college algebra class which is tested during a semester by taking four 50 to 75 minute

examinations each covering several chapters from the course textbook.

Control class.--A college algebra class which participates in minimum testing only.

Frequent testing.--A testing strategy in which two short quizzes per week are given to a college algebra class.

Attitude towards mathematics.--The attitude of a college algebra student towards mathematics as measured by the Aiken-Dreger Revised Math Attitude Scale (24).

Algebra achievement.--The achievement of a college algebra student as measured by the Cooperative Mathematics Test, Algebra II (11).

Arithmetic achievement.--The achievement of a college algebra student as measured by the Cooperative Mathematics Test, Arithmetic (11).

Attrition rate.--Ratio of the number of students who do not complete Math 121 to the number who take the pretest measurements of achievement and attitude.

Limitations

The limitations of this study were

1. The use of intact groups composed of Math 121 classes formed during the regular registration process at Louisiana State University in Shreveport.

2. The only randomization was random assignment of the intact groups to the treatments.

3. Prior educational experience of the subjects was not controlled.

Basic Assumptions

It was assumed that

1. Each experimental treatment would create different degrees of tension within the subjects similar to that discussed in Lewinian field theory.

2. Homework and frequency of testing would fit the distribution of practice and law of exercise theoretical constructs as conceived by Thorndike as well as Hull's reactive inhibition theory.

3. Knowledge of results would be included in each testing strategy with "more" knowledge of results occurring with more frequent testing.

4. The subjects would not be reactive due to the natural setting of the experiment, thus minimizing the Hawthorne effect.

5. The use of a single instructor to administer all treatments would reduce effects due to differences in teaching style or method that might occur if several teachers were used.

6. The instructor would be unbiased in administering the treatments, thus reducing any John Henry effect or experimenter bias.

7. The subjects would respond honestly and conscientiously to the instruments used to measure attitude towards mathematics and achievement in arithmetic and algebra.

Summary

College algebra students have traditionally been tested by many different procedures or a combination of procedures. The concept of testing strategy was introduced in Chapter I and several comparisons were proposed to determine the effects of different types of strategies on performance in college algebra, attitude towards mathematics, and attrition rate. Researchers have investigated several combinations of testing methods for their effects upon performance in and attitude toward various disciplines, but the results have not been consistent enough to decide in favor of any particular testing strategy or combination of strategies.

Kurt Lewin and E. L. Thorndike offer theories suitable for modeling quasi-experimental studies in an educational environment involving testing under differing degrees of "tension" and "practice." The effect these testing strategies have on course performance, attitude, and

attrition has not been sufficiently investigated. The few studies which do exist need refining and extension.

The principal purpose of this study was to determine the effects of four testing strategies upon performance in college algebra, attitude towards mathematics, and attrition rate. Related purposes were to determine if there were significant differences for subsets of these testing strategies relative to the variables of performance, attitude, and attrition.

CHAPTER BIBLIOGRAPHY

1. Aiken, Lewis R., and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52, No. 1 (February, 1961), 19-24.
2. Ammons, R. B., "Rotary Pursuit Performance with Continuous Practice before and after a Single Rest," Journal of Experimental Psychology, 37 (October, 1947), 393-411.
3. Behrman, J. A., Veronica J. Dark, and Stephen C. Paul, "The Effects of a Structured Learning-Skills Intervention on Long-Term Academic Performance," Journal of College Student Personnel, 25 (July, 1984), 326-331.
4. Born, D. G., "Exam Performance and Study Behavior as a Function of Study Unit Size in a PSI Course," Behavior Research and Technology in Higher Education, edited by James M. Johnston, Springfield, IL., Charles Thomas, 1975, pp. 269-282.
5. Davis, James R., Teaching Strategies for the College Classroom, Boulder, Colorado, Westview Press, Inc., 1976.
6. Deutsch, M. and Krauss, R. M., Theories in Social Psychology, New York, Basic Books, 1965.
7. Douthitt, Cameron E., The Effect of Written Examinations on Attitude and Achievement in College Freshman Mathematics at Alvin Community College, (Report No. SE024330), Alvin Community Coll., Texas, (ERIC Doc. No. ED 156 440), 1978.
8. Dustin, D. S., "Some Effects of Exam Frequency," The Psychological Record, 21, No. 3 (Summer, 1971), 409-414.
9. Easley, H., "The Curve of Forgetting and the Distribution of Practice," Journal of Educational Psychology, 28 (September, 1937), 474-478.
10. Gaynor, J., and J. Millham, "Student Performance and Evaluation Under Variant Teaching and Testing

Methods in a Large College Course," Journal of Educational Psychology, 68, No. 3 (June, 1976), 312-317.

11. Handbook Cooperative Mathematics Tests, Monterey, California, CTB/McGraw-Hill, 1964.
12. Hull, C. L., Principles of Behavior, New York, Appleton-Century-Crofts, 1943, pp. 35-49.
13. Kimble, G. A., "An Experimental Test of a Two-Factor Theory of Inhibition," Journal of Experimental Psychology, 39 (February, 1949), 15-23.
14. Kingsley, H. L. and Ralph Garry, The Nature and Conditions of Learning, 2nd ed., Englewood Cliffs, N. J., Prentice-Hall, Inc., 1957.
15. Lewin, Kurt, Field Theory in Social Science. New York, Harper & Brothers, 1951.
16. Maertens, N. and J. Johnston, "Effects of Arithmetic Homework Upon the Attitudes and Achievement of Fourth, Fifth, and Sixth Grade Pupils," School Science and Mathematics, 72, No. 2 (February, 1972), 117-126.
17. Matthes, L. J., "A Comparative Study of the Effects of Required Homework or Quizzes on Achievement in an Undergraduate Mathematics Service Course," unpublished doctoral dissertation, The University of Tennessee, Lynchburg, Tennessee, 1978.
18. McGeoch, J. A., "The Influence of Degree of Interpolated Learning upon Retroactive Inhibition," American Journal of Psychology, 44 (October, 1932), 695-708.
19. Mulry, J. G., "We Need Research on Homework," NEA Journal, 50, No. 4 (April, 1961), 49.
20. National Institute of Education, Involvement in Learning: Realizing the Potential of American Higher Education, Final Report of the Study Group on the Conditions of Excellence in American Higher Education, Washington D.C., Department of Education, 1984.
21. Pedrini, D. T. and Bonnie C. Pedrini, "Reading Abilities and College Grades," College Student Journal, 9, No. 1 (February-March, 1975), 37-42.

22. Schmidt, Gary E., "The Effectiveness of Large Lecture Recitation Sections Versus Small Group Classes and the Influence of Compulsory-Homework-and Quizzes on the Achievement and Attitudes of Calculus II Students," unpublished doctoral dissertation, Department of Education, Kansas State University, Manhattan, Kansas, 1973.
23. Semb, G., "The Effects of Mastery Criteria and Assignment Length on College Student Test Performance," Journal of Applied Behavior Analysis, 7 (Spring, 1974), 60-69.
24. Shaw, Marvin E. and Jack M. Wright, Scales for the Measurement of Attitudes, New York, McGraw-Hill Publishing Company, 1967.
25. Thorndike, E. L., The Psychology of Learning, Vol. 2 of Educational Psychology, New York, Teachers College, Columbia, Univ., 1913.
26. _____, Human Learning, New York, Appleton, 1931.
27. _____, The Fundamentals of Learning, New York, Teachers College, Columbia Univ., 1932.
28. _____, Human Nature and the Social Order, New York: Macmillan, 1940.
29. Townsend, Neal R. and Grayson H. Wheatley, "Analysis of Frequency of Tests and Varying Feedback Delays in College Mathematics Achievement," College Student Journal, 9, No. 1 (February-March, 1975), 32-36.
30. Turney, Austin H., "The Effect of Frequent Short Objective Tests Upon the Achievement of College Students in Educational Psychology," School and Society, 33, No. 858 (June 6, 1931), 760-762.
31. Williams, R. L. and J. Lawrence, "The Effects of Frequency of Quizzing in a Lecture Course," Research and Technology in College and University Teaching, edited by G. W. O'Neill, Georgia State University, Urban Life Center, 1974, pp. 75-82.
32. Verner, Coolie and George S. Davis Jr., "Completions and Drop Outs: A Review of Research," Adult Education, 14 (Spring, 1964), 157-176.

CHAPTER II

SYNTHESIS OF THE LITERATURE

General Research

Dustin (17) and Keys (28) performed studies which culminated in a call for further research to study the relationship between distribution of practice, feedback, and "time on task" relative to performance in college courses. Davis (14) considers a strategy to be any plan, method, or series of activities used to achieve a specific educational goal. "Sound teaching strategies are based upon clear understandings of how people learn" (14, p. 12). Any classroom strategy which seems to help a student perform better would be a worthwhile intervention into daily routines. Procedures for testing in college mathematics classes should be considered important strategies for motivating students to learn content and ultimately to perform well on final examinations. It would be a bonus if these testing strategies also stimulated positive interest in mathematics and helped to relieve the high attrition rate in college algebra classes.

Several studies indicate that further research is needed to help fill the gaps in knowledge about student performance in college courses. Townsend and Wheatley (47)

found that a delay in feedback for some optimum amount of time seemed to increase performance. This is consistent with an extension of the principle of distribution of practice and indicates that rest periods between practice sessions seem to increase performance and enhance learning (5).

Behrman, Dark, and Paul (9) related that various factors which influence academic performance are complex and not well understood. They suggested a need for investigations to develop a model incorporating a variety of improvements in course interventions designed to increase performance.

Douthitt (16) pointed out that instructors should give more attention to methods other than infrequent major written examinations to increase performance in mathematics. He suggested that ". . . methods of evaluation requiring more frequent evaluation and active student involvement in demonstrating their knowledge in mathematics should be investigated" (p. 6).

A recent article by Zorn (54) indicated that little feedback on regular assignments is being given to students in college calculus classes. A trend is developing toward large failure rates, and those who do pass calculus are far from understanding the basic concepts. The current status of calculus (the basic building block of mathematics) is one of chaos. Recommendations for new ways of teaching,

testing, and administering calculus are forthcoming. In particular, a move is underway to devise strategies (54) for improving calculus as presently taught in colleges and universities. College algebra is related to calculus in a way similar to the relationship between calculus and mathematics. Problems like the one above are being encountered in algebra classes; consequently a similar need exists to investigate ways and means to improve attitudes, performance, and retention.

Research on Frequent Testing

In 1923, Harold E. Jones did the pioneering work related to frequent testing and its effect on performance with his study, "The Influence On Learning And Retention of Weekly As Opposed To Monthly Tests" (27). He discovered that classes tested immediately after each lecture profited so much that, after eight weeks, almost twice as much of the content was retained as content not similarly examined.

A later study by Turney (49) on the effect of frequent, short, objective quizzes upon the achievement of college juniors and seniors in educational psychology yielded significant results. Two groups were constructed from pre-testing with the group having lower mean score being chosen as the experimental group. Pre-test scores of 85.2 to 108.1 showed that the experimental and control groups differed widely in initial knowledge of educational

psychology. It should be noted that both groups had nearly the same mean score on the Miller Mental Ability Test, Form B. This experiment revealed that the differences between the experimental group and the control group on the pre-test, and in gains, were significant. The only reported difference in the treatment of the two groups was the giving of thirteen intermediate tests to the experimental group as contrasted with two to the control group. According to Keys (28, p. 427), Turney's experiment ". . . suffers from the fact that the two sections differed so widely in initial knowledge of the subject."

Keys (28) distinguished his study from the ones preceding by having tests, identical in content and total amount, administered to the two groups. The groups differed only in treatment with the experimental group taking these tests in brief weekly installments, and the control taking longer mid-term examinations. In addition, this study was different from earlier ones because no attempt was made to use the tests for instruction by way of feedback. Tests were not returned for review and correction in class, nor were preparatory quiz sessions of any type provided. Finally, the number of subjects in the groups were from two to ten times those in previous investigations. On the regular final examination, the groups did not differ significantly in measure of retention of content. But the same tests given weekly rather than

monthly resulted in significantly higher mean performance by the experimental group. Keys also administered a questionnaire to collect opinions from students about tests and assignments. The questionnaire was given at the beginning and end of the term and showed a significant growth in the conviction that students prefer "more frequent examination."

Dustin (17) did a partial replication of Key's 1934 experiment by randomly splitting a college psychology class into halves. The first half of the class took four different examinations each week for four weeks. The second half took all four examinations in the fourth week as if it were a single examination. All subjects received minimal feedback from the examination results. The weekly-exam group showed significantly higher mean scores on 3 of the 4 tests when compared with the test scores of the monthly-exam group. Also the weekly-exam group had a significantly smaller increase in test anxiety over the 4 weeks, and a significantly higher score on a delayed retention test covering material from the first week's test. Dustin concluded that examination frequency affects test performance in some way independent of feedback. Apparently, more frequent examinations together with a proper feedback procedure will tend to maximize students' examination and retention scores and will reduce testing anxiety.

Williams and Lawrence (51) confirmed results of Gaynor and Millham (20) as well as Semb (41), that frequent quizzes over small units of material aid students in performing better on later major examinations than students who are tested less frequently over larger units. Gaynor and Millham found that academic performance was significantly affected by teaching conditions and testing methods. Semb found that frequent testing yielded maximum student test performance, and he maintained that the reason for this increased performance is ". . . far from answered, but the present data do suggest that short assignments produce better performance than long assignments, for whatever reason" (p. 69).

A study done with large lecture classes produced results which caused Fitch, Drucker, and Norton (18) to conclude that frequent testing of achievement in the college lecture classroom may motivate the student to employ the proper outside activities as will result in superior achievement. They also found that the motivation is enhanced if the instructor supplements his lecture with instructional materials and experiences closely related with course content.

Martin and Srikameswaran (30) proposed that allowing students more grade credit (weight) for frequent quizzes in figuring their final grade would probably cause a more pronounced improvement in performance. "Such a move could

promote greater interaction between instructor and student, aiding the learning process" (p. 486).

Matthes (32) got different results when he compared three groups of students in a freshman mathematics service course upon final examination scores. One group had required homework and no quizzes, one had daily quizzes and did only voluntary homework, and the control group had neither quizzes nor homework. Matthes reported that at the .05 level no statistical difference in mean final examination scores was found.

In a study done by Townsend and Wheatley (47), 442 beginning calculus students in 16 classes ranging in size from 11 to 35 were arranged in a two-by-four-by-three factorial design with two observations (classes) per cell. The three fixed factors were D = delay of feedback of test results (two levels), T = frequency of tests (four levels), and A = aptitude (three levels). Each of eight pairs of classes were randomly assigned to one of the eight cells in the test frequency-feedback delay treatments. Three aptitude subgroups were identified in each class by using the aptitude portion of the Scholastic Aptitude Test. Mathematics achievement was the criterion variable and was measured by a test constructed especially for this study. Concomitant variables were mean class size and the proportion of student withdrawals from class. A three-factor analysis of covariance was used to test for

differences among cell means for achievement, and a chi-square test for differences in dropout proportions was used. Two-way analysis of variance was used to test for differences among the cell means for each of the concomitant variables and for differences in attitude. The results of this study were

1. Classes to which short daily quizzes were assigned had significantly higher achievement in performance than classes given only a midterm examination. All other differences among means for the four levels of test frequency were not significant. This result gives additional evidence that short frequent tests positively affects achievement;

2. Classes in the long delay for feedback cell had significantly higher achievement test adjusted mean scores than those in the short delay cell. Apparently, discussion of test results after some period in which other topics are studied serves as an effective review and enhances learning (at least for the subjects of this study);

3. No significant interaction effects were found permitting the conclusion that students' aptitudes do not need to be of prime consideration in deciding feedback procedures and testing strategies for freshmen calculus students; and

4. The various levels of feedback and testing frequency did not result in significant differences in attitude nor in proportion of students who withdrew from the classes.

Research studies dealing with frequent testing usually compare it with less frequent in-class testing procedures. But Gaynor and Millham (20) saw a need for another type of comparison. They compared frequent testing and student-paced evaluation methods. It appears that an area of further investigation might be to compare the relative effectiveness of frequent testing and other types of strategies upon performance in mathematics.

Homework Research

Most research on homework has been concerned with whether homework was better than no homework (19). Studies done prior to 1950 were unfavorable to homework (43). Goldstein (21) reported that unfavorable conclusions were sometimes drawn from studies where the evidence did not support such conclusions. He reviewed thirty years of research on homework and concluded that ". . . preconceived ideas about the value of homework have often interfered with the interpretation of research findings" (pp. 7-8). Goldstein found most of the research on homework to be inconclusive and statistically insignificant. The studies with significant results suggested that homework favors

higher academic achievement for some students in some subjects.

Anderson (6) did a study in 1946 with twenty-nine students in each of two groups. One group received homework assignments and the other did not have homework. Higher achievement gains were found in English, social studies, and mathematics for those students who did homework. It should be noted that Anderson found bright students fared almost equally as well in each group, while average and below average students in the non-homework group were much less successful than similar students in the homework group.

A synthesis of the literature revealed several comparisons between frequency of quizzing and required homework relative to achievement and attitude towards mathematics. A study done by Schmidt (40) in 1973 compared calculus II students in two groups: those who had required homework and no quizzes and those who had weekly quizzes and no required homework. No statistically significant difference in mean achievement of the two groups occurred. No significant difference in posttest attitude, and no relationship between achievement and attitude was discovered. The groups were equated statistically by using ACT score, calculus I grade, and pretest attitude as covariates. Another related study done by Cartledge and Sasser (10) in 1981 revealed different results. One group

of fifteen freshmen algebra students was assigned homework while another group of fifteen did no homework. Mathematics achievement of the homework group was significantly greater at the .01 level than the no homework group. No attitude check was done.

In a study involving larger numbers of subjects, Mason (31) considered the advantages of requiring homework. There were 241 students in the required homework group and 191 in the non-homework group. Each of the teachers used in the study taught a homework class and a non-homework class. No significant differences were found in achievement between the homework and the non-homework group when averaged over all teachers. The interaction of teacher by method had a significance level of .005. Mason's conclusion was that each teacher should determine which of the two methods to use in order to be most effective as a teacher.

Maertens (29) used 342 arithmetic pupils in 1968 randomly assigned to nine classrooms in three schools. Books and curriculum were constant and the teachers followed their normal instructional procedures during the experiment. The only variable was the type and amount of homework. The statistical analysis indicated that homework had no significant effect upon arithmetic achievement as measured by tests of knowledge of arithmetic processes, computational skill, and problem solving ability. There

were no significant differences relative to intelligence within the three ability levels. The effect of homework upon attitudes of students toward school, arithmetic, teacher, and reading was not significant. Ability level did not appear to have a significant effect upon attitudes.

Taylor (44) compared the effects of two testing strategies on the achievement and attitude of Algebra I and Geometry I students. One approach involved compulsory homework, with the work graded and returned by the teacher. The other was a non-compulsory approach, i.e., no homework was evaluated by the teacher. After eighteen weeks, achievement and attitude tests were administered. There was no significant difference in the two groups relative to achievement and attitude. Compulsory homework could not be justified on the basis of achievement and attitude scores alone. However, compulsory homework was vigorously endorsed by both students and parents on a questionnaire administered during the course of the study.

A study done in 1976 by Parrish (36) involved 234 students. Two teachers each taught four classes of ninth grade Fundamentals of Mathematics. The principal topic covered was percentage. Two classes from each teacher were randomly selected to be the drill homework group. No homework was collected in the other two classes for each teacher. Data from a random sample of fifteen sets of scores from each of the eight classes were analyzed.

Parrish found a significant difference in achievement favoring the drill homework group. There was no difference in attitudes toward mathematics.

A public two-year college in California was the setting for Hansen's (24) study in which three mathematics classes were divided into experimental and control groups. A trigonometry and two calculus classes were used with the experimental groups receiving homework assignments which were collected, promptly graded and returned. One of the calculus classes did not receive credit for the homework. The control groups did not receive homework assignments. Standardized achievement tests were administered at the beginning and end of an eight week experiment period to measure achievement gains. No significant differences occurred between the adjusted means of the posttest scores of the two groups. The trigonometry homework group scored higher than the no-homework group on two investigator-designed examinations. Hansen kept study-time logs on each student and found that the trigonometry and calculus homework students (1) spent more time in study than did the no-homework students, and (2) had fewer days of no study and more days of uninterrupted study.

Friesen's (19) analysis of twenty-four research studies from the years 1923 to 1976 dealing with homework as a testing strategy showed that the use of homework in hopes of increasing performance in mathematics classes

could not be endorsed or refuted as significant. Cartledge and Sasser (10), Mulry (34), and Hines (25) indicate a real need for further research into the positive and negative effects of homework upon performance in mathematics. In particular, Mulry called for additional well-defined research into the problem. Cartledge and Sasser reinforced Mulry's charge by concluding from their study of homework versus no homework groups that "Until more efficient methods . . . are developed, it would seem that further research in this area is unlikely to have much payoff" (10, p. 11). Hines work was in two high school plane geometry classes. He used nineteen pairs matched by age, intelligence, and first-year algebra grades and then randomly assigned each group of nineteen to the two classes. The control group received homework two or three times each week while the experimental group received no homework. He found that out-of-class study, usually written work, increased achievement of the average student by about one letter grade in a traditional grading system using A, B, C, D, and F. Hines suggested that his study had limitations which other studies with refined designs could remedy. He said that ". . . a few dozen such studies would give definitive answers to some questions in the homework versus no-homework argument" (25, p. 29).

Homework is a testing strategy which is not of the same type as frequent testing. It is not an in-class type

of written examination. Only two research studies have been located which consider a comparison of frequent testing and homework (32, 40) and in both cases no significant difference was found. The present study was different from these two studies in that the frequent testing and homework strategies were more nearly mutually exclusive. Also, the subjects in the two groups were equated with respect to variables not considered earlier.

Research on Attitude Towards Mathematics

Several investigations have dealt with analyzing the causes of student difficulties with mathematics. Reports from Weaver (50), Gough (22), and Poffenberger and Norton (37) indicate a research interest in discovering what makes students afraid of mathematics, especially when many of these students make high grades in other subjects. Tulock (48) investigated emotional blocks of mathematics students and found that a series of steps can be taken by mathematics teachers to alleviate such conditions. McCallon and Brown (33) as well as Shaw and Wright (42) believe that if the attitude of a person toward an object or concept can be discerned, then this information can be used with other variables in the context of the situation to predict and explain reactions of the person to that object or concept.

Aiken (1, 2, 3, 4) conducted considerable research on the association between mathematics attitudes and achievement

as well as other intellectual factors. With mathematical ability held constant, two hypotheses were offered to account for attitudes toward mathematics (2). The simpler hypothesis indicates that the specific pattern of reward the individual receives for doing well in mathematics determines the attitude toward mathematics. This hypothesis does not seem to account for quite different attitudes toward mathematics which have been discovered for individuals with similar mathematical ability and patterns of reward in their mathematics backgrounds. The other hypothesis is that mathematics attitude is related to general personality traits. A specific test instrument was developed by Aiken and Dreger (1) to investigate mathematics attitude. The Mathematics Attitude Scale (MAS) yielded a test-retest reliability of .94 upon preliminary investigation. The test was developed by reducing paragraphs written by 310 college students to twenty Likert-type test items. There were 10 items related to a positive attitude and ten relating to a negative attitude towards mathematics.

Multiple regression analyses of the predictive value of the (MAS) was tested using sixty males and sixty-seven females registered for general mathematics in college. Using correlations between each of five intellectual factors and the dependent variable (final grades), the independent variables of high school mathematics average,

Differential Aptitude Tests (DAT) Verbal, DAT Numerical Ability, and the MAS were chosen for the regression analyses. The multiple correlation coefficients were .67 for males and .63 for females ($p < .01$). Partial regression coefficients showed that all variables except the MAS made significant contributions for males. Only MAS and DAT Numerical Ability were important for the females. Therefore, the hypothesis that mathematics attitude is significant in predicting achievement in mathematics is true for females, but not for males. Regression and correlation analyses of the intercorrelations of the intellectual factors with grades in high school and college mathematics courses supported hypotheses that direct experiences in relation to mathematics contribute to mathematics attitudes.

Neale (35) published a paper in 1969 where he successfully showed that not only do attitudes affect achievement in mathematics but achievement also affects attitudes. Aiken's findings show that certain traditional practices such as homework tend to create positive attitudes toward mathematics. He indicated that further research using a whole complex of variables needs to be undertaken if more complete statements about attitudes toward mathematics are to be made (1, 2, 3, 4).

A longitudinal study by Anttonen (7) was conducted from 1960 to 1966 to investigate the relationship between

attitude and achievement in mathematics. As a result Anttonen suggested that future studies over shorter time periods should be undertaken with attempts to change students' attitudes toward mathematics. A positive change in attitude could lead to better performance and greater comfort in mathematics classes. Significant procedures for changing mathematics attitudes positively would be useful in curing or at least controlling "mathemaphobia."

Attrition-Retention Research

Most attrition research is related to counting the number of dropouts rather than finding solutions to the problem. According to Astin (8), classifying and describing dropouts as well as counting their numbers has come to be a preoccupation with researchers, but little is being done to define the causes of high attrition among college students. Various studies reveal that 33 to 75 percent of remedial and developmental students drop out of college each year (11, 26). Roueche (39) found that dropout rates among the poor reach as high as 70 percent.

In a factor analysis study of self-reported problems accounting for dropping out of college, Cope and Hewitt (13) found that 62 percent of the total variance was explained by the factors: family, finance, social, academic, discipline, club membership, and religion. In another study, the Texas Education Agency (45) said that

14 percent of the dropouts had conflicting job hours; 13 percent had grade problems; and 28 percent dropped out due to attendance problems. In a survey by Thompson (46), over 3,568 students who dropped 6,081 courses at McComb County Community College gave a variety of reasons for dropping out. Popular reasons were lack of interest, job conflicts, wrong program, conflicts with teachers, and academic difficulty.

Other research approaches have been to try to identify personological variables or specific aptitudes of students who drop out of college (15, 16). In particular, Wilson (52) found a consistent "dropout" profile when he used the Adjective Check List (ACL) measurement to study dropouts. Students who withdrew from school ranked higher in measures of heterosexuality and change, but were lower on achievement, endurance, and order. These students seemed to be more hostile, impatient, indifferent to the feelings of others, comfortable with disorder, desirous of attention, and required more supportive and dependent involvement. They were less task-oriented, short in attention span and endurance, and unwilling to take orders from others. In a related study by Hannah (23), a comparison of students who drop out with those who stay in college showed that those whose thinking is unnecessarily complex, who accept ambiguity, who react overtly to impulses, who are more hostile, aggressive, and anxious, and who tend to have a

low self concept will, more often than not, be among the group of dropouts. A research review done by Verner and Davis (53) revealed that thirty studies dealing with attrition in adult education named twenty-six personal factors which were studied in an attempt to identify characteristics of persons who "stay-in" college. Among the variables related to persistence were age, education, marital status, occupation, income, and rate of social participation.

The idea of a "dropout" personality is rejected by Cope and Hewitt (12) in their writings. They insist that the dropout phenomenon is a complex series of interactions between the student and the institutional environment.

Summary

A review of available research appears to yield inconclusive results about comparisons involving students who are exposed to different testing strategies such as required homework, frequent quizzing, less frequent unit examinations, and no required work or testing prior to midsemester or final examinations. It appears that these testing strategies for student involvement are not related to a posttest change in attitude toward mathematics. Attrition rate has been studied in the broad context of college dropouts with relatively little literature on

causes for high attrition rates within particular disciplines.

The potential for meaningful change in the teaching of mathematics is open. Dramatic advances in technology will soon change what is taught in mathematics as well as how it is taught.

Research on learning and research on teaching are on the threshold of providing the kinds of knowledge that could lead to real advances in mathematics instruction. Change is inevitable. If we can build upon a solid knowledge base derived from research on teaching and learning, the change could result in real progress in the teaching and learning of mathematics (38, p. 869).

CHAPTER BIBLIOGRAPHY

1. Aiken, Lewis R., and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52, No. 1 (February, 1961), 19-24.
2. Aiken, Lewis R., "Personality Correlates of Attitude Toward Mathematics," The Journal of Educational Research, 56, No. 9 (May-June, 1963), 476-480.
3. _____, "Research on Attitudes Toward mathematics," The Arithmetic Teacher, 19, No. 3 (March, 1972), 229-234.
4. _____, "Two Scales of Attitude Toward Mathematics," Journal for Research in Mathematics Education, 5, No. 2 (March, 1974), 67-71.
5. Ammons, R. B., "Rotary Pursuit Performance with Continuous Practice before and after a Single Rest," Journal of Experimental Psychology, 37 (October, 1947), 393-411.
6. Anderson, William E., "An Attempt Through the Use of Experimental Techniques to Determine the Effect of Home Assignments Upon Scholastic Success," Journal of Educational Research, 40, No. 2 (October, 1946), 141-143.
7. Anttonen, Ralph G., "A Longitudinal Study in Mathematics Attitude," The Journal of Educational Research, 62, No. 10 (July-August, 1969), 467-471.
8. Astin, Alexander W., Preventing Students from Dropping Out, San Francisco, Jossey-Bass, 1975.
9. Behrman, J. A., Veronica J. Dark, and Stephen C. Paul, "The Effects of a Structured Learning-Skills Intervention on Long-Term Academic Performance," Journal of College Student Personnel, 25 (July, 1984), 326-331.
10. Cartledge, Carolyn M. and John E. Sasser, The Effect of Homework Assignments on the Mathematics Achievement of College Students in Freshman

- Algebra, (Report No. SE035577), Georgia, (ERIC Document Reproduction No. ED 206 495), 1982.
11. Cohen, Arthur M., Dateline '79: Historical Concepts for the Community Colleges, Beverly Hills, Glencoe Press, 1969.
 12. Cope, Robert G. and Raymond William Hewitt, Revolving College Doors: The Causes and Consequences of Dropping Out, Stopping Out, and Transferring, New York, John Wiley and Sons, 1975.
 13. _____, "Types of College Dropouts: An Environmental Press Approach," College Student Journal, 5 (September, 1971), 46-51.
 14. Davis, James R., Teaching Strategies for the College Classroom, Boulder, Colorado, Westview Press, Inc., 1976.
 15. DeVechio, Richard C., "Characteristics of Nonreturning Community College Freshmen," The Journal of College Student Personnel, 13 (September, 1972), 429-432.
 16. Douthitt, Cameron E., The Effect of Written Examinations on Attitude and Achievement in College Freshman Mathematics at Alvin Community College, (Report No. SE024330), Alvin Community Coll., Texas, (ERIC Document Reproduction No. ED 156 440), 1978.
 17. Dustin, D. S., "Some Effects of Exam Frequency," The Psychological Record, 21, No. 3 (Summer, 1971), 409-414.
 18. Fitch, Mildred L., A. J. Drucker, and J. A. Norton, Jr., "Frequent Testing As A Motivating Factor In Large Lecture Classes," The Journal of Educational Psychology, 42, No. 1 (January, 1951), 1-20.
 19. Friesen, C., The Results of Homework Versus No-Homework Research Studies, paper presented to the University of Iowa, (ERIC Document Reproduction No. ED 167 508), 1979.
 20. Gaynor, J., and J. Millham, "Student Performance and Evaluation Under Variant Teaching and Testing Methods in a Large College Course," Journal of

Educational Psychology, 68, No. 3 (June, 1976), 312-317.

21. Goldstein, Avram, "Does Homework Help? A Review of Research," The Elementary School Journal, 60 (January, 1960), 212-224.
22. Gough, M. F., "Mathemaphobia: Causes and Treatments," Clearing House, 28, 1954, pp. 290-294.
23. Hannah, William, "Personality Differences Between Lower Division Dropouts and Stay-Ins," The Journal of College Student Personnel, 12 (January, 1971), 12, 16-19.
24. Hansen, David W., "An Investigation of the Effects of Required Homework on Achievement in Mathematics," Dissertation Abstracts International, 33 (December, 1972), 2814A-2815A.
25. Hines, V. A., "Homework and Achievement in Plane Geometry," The Mathematics Teacher, 50 (January, 1957), 27-29.
26. Hoyt, Donald P., "A Retrospective and Prospective Examination of Retention-Attrition Research," In Reducing the Dropout Rate, edited by Lee Noel, San Francisco, Jossey-Bass, 1978, pp. 77-85.
27. Jones, Harold E., "Experimental Studies of College Teaching," Archives of Psychology, 68, (1923), pp. 1-62.
28. Keys, Noel, "The Influence of Learning and Retention of Weekly as Opposed to Monthly Tests," The Journal of Educational Psychology, 25 (September, 1934), 427-436.
29. Maertens, N. and J. Johnston, "Effects of Arithmetic Homework Upon the Attitudes and Achievement of Fourth, Fifth, and Sixth Grade Pupils," School Science and Mathematics, 72, No. 2 (February, 1972), 117-126.
30. Martin, R. R. and Kam Srikameswaran, "Correlation Between Frequent Testing and Student Performance," Journal of Chemical Education, 51, No. 7 (July, 1974), 485-486.
31. Mason, Lysle C., "A Study of the Influence of Compulsory Homework on the Achievement of College

Students in College Algebra," Dissertation Abstracts International, 28 (July, 1967), 56A.

32. Matthes, L. J., "A Comparative Study of the Effects of Required Homework or Quizzes on Achievement in an Undergraduate Mathematics Service Course," unpublished doctoral dissertation, The University of Tennessee, Lynchburg, Tennessee, 1978.
33. McCallon, Earl L., and John D. Brown, "A Semantic Differential Instrument For Measuring Attitude Toward Mathematics," The Journal of Experimental Education, 39, No. 4, 1971, pp. 69-72.
34. Mulry, J. G., "We Need Research on Homework," NEA Journal, 50, No. 4 (April, 1961), 49.
35. Neale, Daniel C., "The Role of Attitudes in Learning Mathematics," Arithmetic Teacher, 16 (December, 1969), 631-640.
36. Parrish, D. C. "An Investigation of the Effects of Required Drill Homework Versus No Homework on Attitudes Toward and Achievement in Mathematics," unpublished doctoral dissertation, University of Houston, Houston, Texas, 1976.
37. Poffenberger, T. N., and D. A. Norton, "Factors Determining Attitudes Toward Arithmetic and Mathematics," Arithmetic Teacher, 3, 1956, pp. 113-116.
38. Romberg, Thomas A., and Thomas P. Carpenter, "Research on Teaching and Learning Mathematics: Two Disciplines of Scientific Inquiry," Handbook of Research on Teaching, 3rd ed., edited by Merlin C. Wittrock, New York, Macmillan Pub. Co., 1986, pp. 850-873.
39. Roueche, John E., George A. Baker III, and Richard L. Brownell, Accountability and the Community College, Washington, American Association of Junior Colleges, 1971.
40. Schmidt, Gary E., "The Effectiveness of Large Lecture Recitation Sections Versus Small Group Classes and the Influence of Compulsory-Homework-and-Quizzes on the Achievement and Attitudes of Calculus II Students," unpublished doctoral

- dissertation, Department of Education, Kansas State University, Manhattan, Kansas, 1973.
41. Semb, G., "The Effects of Mastery Criteria and Assignment Length on College Student Test Performance," Journal of Applied Behavior Analysis, 7 (Spring, 1974), 60-69.
 42. Shaw, Marvin E. and Jack M. Wright, Scales for the Measurement of Attitudes, New York, McGraw-Hill Publishing Company, 1967.
 43. Swensen, Ester J., James C. Cost, and Greene Y. Taylor, "Research on Homework," Journal of Education, 137 (March, 1955), 20-22.
 44. Taylor, Harold D., "A Comparative Study of Compulsory Homework Versus Non-Compulsory Homework in Algebra I and Geometry I at Hillsdale High School," Dissertation Abstracts International, 32 (January, 1972), 3876A.
 45. Texas Education Agency, Course Withdrawal Data Summary--Fall 1976, Texas-SIS Follow Up, Postsecondary Student Follow-Up Management Information System, (Monograph 2), Austin, Texas, (Eric Document Reproduction No. ED 140 905), 1977.
 46. Thompson, J. Robert, Why Students Drop Courses, McComb County Community College, (Eric Document Reproduction No. ED 026 994), 1969.
 47. Townsend, Neal R. and Grayson H. Wheatley, "Analysis of Frequency of Tests and Varying Feedback Delays in College Mathematics Achievement," College Student Journal, 9, No. 1 (February-March, 1975), 32-36.
 48. Tulock, M. K., "Emotional Blocks in Mathematics," Mathematics Teacher, 50, 1957, pp. 572-576.
 49. Turney, Austin H., "The Effect of Frequent Short Objective Tests Upon the Achievement of College Students in Educational Psychology," School and Society, 33, No. 858 (June 6, 1931), 760-762.
 50. Weaver, H. B., "The Mathematical Proficiency of Students of Psychology," Journal of Educational Research, 51, 1957, pp. 161-170.

51. Williams, R. L. and J. Lawrence, "The Effects of Frequency of Quizzing in a Lecture Course," Research and Technology in College and University Teaching, edited by G. W. O'Neill, Georgia State University, Urban Life Center, 1974, pp. 75-82.
52. Wilson, Russell C., "Personological Variables Related to GED Retention and Withdrawal," Adult Education, 30 (Spring, 1980), 173-185.
53. Verner, Coolie and George S. Davis Jr., "Completions and Drop Outs: A Review of Research," Adult Education, 14 (Spring, 1964), 157-176.
54. Zorn, P., "Calculus Redux," Focus, 6, No. 2 (March-April, 1986), 1-2, 5.

CHAPTER III

PROCEDURES FOR THE COLLECTION OF DATA

Introduction

Louisiana State University in Shreveport (LSU-S) is a branch campus of LSU in Baton Rouge, Louisiana. LSU-S is a four-year degree-granting institution located in a growing area of approximately 300,000 population and has an enrollment of about 4,500. LSU-S is a commuter university with no on-campus housing. Traditional high school graduates constitute a large portion of the student body, but many non-traditional and older students also attend. The mathematics department offers a college algebra course (Math 121) which is used as a service course for many curricula and a precalculus course for mathematics majors. In this study, data were collected in four Math 121 classes taught at LSU-S during the fall semester of 1986.

Population and Sample

The population for this quasi-experimental study was composed of students who enrolled for college algebra classes (Math 121) at LSU-S in the fall semester of 1986. Four of these classes were assigned to the experimenter (teacher) through regular scheduling procedures performed by the mathematics department chairman. The classes used

were scheduled at 9:00 and 10:00 a.m. Monday-Wednesday-Friday and 9:30 and 11:00 a.m. Tuesday-Thursday. These classes had initial enrollments of forty to forty-five students per class. Ten classes of Math 121 were offered in the fall semester, and students were free to choose the class in which they would enroll. It was assumed that the four classes assigned were homogeneous and representative of a typical LSU-S Math 121 college algebra class. These four classes constituted the sample for the experiment.

Experimental Variables

The independent variable was testing strategies. There were four levels of this variable, each level being a different testing procedure or plan. Other independent variables consisted of covariates selected from algebra achievement, arithmetic achievement, and attitude towards mathematics. Dependent variables were performance in college algebra, attitude towards mathematics, and attrition rate.

Research Design

A quasi-experimental research design was used to determine if testing strategies have a causal effect on performance in college algebra, attitude towards mathematics, and attrition rate. The Nonequivalent Control Group Design #10 as described by Campbell and Stanley (5, p. 47) was the design chosen for this study.

The experimental research design provides the most rigorous test to establish cause-and-effect relationships between two or more variables. Borg and Gall (2) claim that even though experiments in educational settings are not easy to conduct and control, they are the ultimate form of research design.

There are many natural social and educational settings in which the researcher can introduce procedures close to those of an experimental design where just the randomization process of a true experimental design is lacking. Campbell and Stanley (5) classify such situations as quasi-experimental designs.

The Nonequivalent Control Group Design can be diagrammed as

$$\frac{O}{O} - X - \frac{O}{O}$$

where O represents a pretest or posttest group and X a treatment. This design is an important quasi-experimental design and should not be confused with the Pretest-Posttest Control Group Design which is a true experimental design with randomization control. But Design #10 should be recognized as a worthwhile design since it can be used where true experimental designs are either not possible or not practical to apply. Campbell and Stanley succinctly describe this research design with the following:

One of the most widespread experimental designs in educational research involves an experimental

group and a control group both given a pretest and a posttest, but in which the control group and the experimental group do not have pre-experimental sampling equivalence. Rather, the groups constitute naturally assembled collectives such as classrooms, as similar as availability permits but yet not so similar that one can dispense with the pretest. The assignment of X to one group or the other is assumed to be random and under the experimenter's control (5, p. 47).

Description of the Instruments

To measure the concomitant variables of this experiment, the following instruments were utilized:

1. The Aiken-Dreger Revised Math Attitude Scale (RMAS) was administered at the beginning of the course to measure pre-treatment attitude towards mathematics. Shaw and Wright (9, p. 242) described the RMAS as ". . . satisfactory with regard to both its reliability and validity." A test-retest reliability coefficient of .94 was reported by Aiken and Dreger (1). Validity was established by a test of independence between the scores on the attitude scale and scores on four other items inserted to measure attitudes toward academic subjects other than mathematics. A chi-square value of .80 with one degree of freedom was obtained. A copy of this instrument is in Appendix F.

2. To measure pre-treatment algebra achievement, form A of the Cooperative Mathematics Test, Algebra II (CMTII) was used. It is suggested that this objective test be used to measure achievement in topics dealt with in at

least the first half of the second-year of high school algebra. Travers (10) stated that prospective users of the CMTII will find these topics adequately sampled. Content validity was established by well-qualified reviewers, but a recommendation was made ". . . that each test user make an individual judgment of content validity with respect to his own course content and educational aims" (6, p. 62). The Kuder-Richardson Formula 20 (K-R 20) reliability coefficient for form A was reported to be .84 based on randomly selected subsamples from high school grades ten through twelve. Concurrent validity was established by a correlation of .62 between the CMTII, form A and the Quantitative score on the School and College Ability Test (SCAT-Q) (6).

3. Objective measurement of pre-treatment arithmetic achievement was accomplished by using form A of the Cooperative Mathematics Test, Arithmetic (CMTA). Attesting to the validity of an equivalent form, Osborne (8, p. 914) stated that "The scope of arithmetical concepts tested is as comprehensive as that of most competitive tests." He further claimed that all forms of the CMTA are ". . . thorough tests of arithmetic content . . ." (p. 915). Concurrent validity was established with a correlation of .74 between the CMTA and SCAT-Q. Reliability for form A was calculated by K-R 20 to be .86 by using a randomly

selected sample of students from grade levels seven, eight, and nine (6).

To measure the dependent variables, the following instruments were utilized:

1. Posttest attitude towards mathematics was measured with the RMAS.
2. Post-treatment performance in college algebra was measured using form A of the Cooperative Mathematics Test, Algebra III (CMTIII) (3). The developers of this objective test contend that carefully devised procedures were followed to ensure maximum content validity. An elaborate system of experts in testing, curriculum, and subject matter were used in its development (6).

Concurrent validity was established with a correlation coefficient of .58 relating the CRTIII and the (SCAT-Q) (6). The coefficient was .60 for an equivalent form of CMTIII (11). Kohler (7) reported a predictive validity correlation coefficient of .53 ($N = 158$) between the CMTIII and college algebra grade point average. An alpha reliability coefficient of .76 was also reported. A K-R 20 reliability was reported as .84 for this 40 item test (6). Warrington (11, p. 899) claimed that ". . . this test is acceptable for evaluating achievement in algebra at the first course level in college." Caldwell (4, p. 897) said ". . . Algebra III is probably superior to any other existing college algebra test."

Permission to use the RMAS was given by personal correspondence with Dr. Lewis R. Aiken on April 10, 1986 (see Appendix I). The CMTII, CMTA, and CMTIII were purchased for use from Publishers Test Service, CTB/McGraw Hill in Monterey, California (see Appendix J).

Data Collection

During the first class period of the fall semester, the RMAS and CMTA were administered as part of the normal introductory class procedure. The CMTII and demographic data sheet were given during the second class meeting. Pretesting took a total of ninety minutes. The tests were administered as indicated so that the students would not be aware of any change from an ordinary mathematics class. The students were told by the experimenter that the tests would be incorporated into their overall evaluation.

The final examination period was scheduled for 120 minutes at which time the RMAS and CMTIII were given. During this time an opinionnaire was administered to determine which testing strategies were preferred by the students involved in the experiment (see Appendix H). A count of students who completed the course was also made to compute the attrition rate for each class. Every student was required to take a final examination to receive credit for the course at LSU-S, so criterion scores were collected for each student who completed Math 121.

Control Procedures

Four Math 121 classes were assigned to the four types of testing strategy (independent variable levels) using a table of random numbers. In an attempt to control for variations in teaching style, and time of class, all four classes were taught in morning sessions by the same teacher using a traditional and conventional lecture-problem-solving classroom procedure. All classes were told that homework is necessary in the course, and that attendance is mandatory. Excused absences were accepted and all work missed was made up by the student.

All four classes were given an objective midsemester and final examination. The midsemester examination was a multiple choice examination prepared by the instructor. It covered all the material through half of the semester: approximately seven weeks. This test counted 50 percent of the final course grade for the students in the control class and 25 percent of the course grade in each of the other three classes. The final examination was the CMTIII. This test counted 50 percent of the final course grade for the students in the control class and 25 percent for the students in each of the other three classes. The final examination measured one of the three criterion variables in this study: performance in college algebra.

Procedure for Applying Treatments

The first part of each class was used to answer questions from previous homework assignments. The homework class was required to hand in written homework assignments two class periods per week, while the other three treatment classes were assigned exactly the same homework, but were not asked to submit it for grading. Required homework was graded and counted 50 percent of the final course grade for each student in the homework class.

The quiz class was given a short ten to fifteen minute test on the previous class meeting's homework assignment two times per week. The quiz was administered during the last part of the class period following the homework question session and the presentation of the lecture material for that class period. Each quiz consisted of representative problems or questions directly from the student's homework assignment. Quizzes were graded and averaged for each student in the quiz class. This average counted 50 percent of the final course grade for each student in the Quiz class.

Four major examinations (infrequent long quizzes) were given to the test class over the course of the semester. Each examination was a maximum of fifty to seventy-five minutes in length and covered material since the last major examination, i.e., it was not cumulative. The average of these four objective tests counted 50 percent of the final course grade for each student in the test class.

The control class was not given required homework, in-class quizzes, or major examinations except for the midsemester and final examinations. Only minimum treatment overlap should have occurred among the quiz class, homework class, test class, and control class so the four classes were considered to be mutually exclusive relative to levels of the independent variable.

Experimental Validity

Campbell and Stanley (5, p. 14) indicate that threats to internal validity for the Nonequivalent Control Group Design are limited to interaction of selection and maturation, and possibly regression. It was assumed that the maturation possibilities for the students in the treatment groups were controlled by the environment and methods outlined above to collect the data. Regression was controlled by the random assignment of classes to treatments as well as by using covariate analysis in the interpretation of data (2, p. 683). To control for experimental treatment diffusion (2, p. 637), a course syllabus and information sheet were given to each student. Copies of these can be seen in Appendices A through E. They provided information relative to testing, grading, and attendance as well as course organization, procedures, and student evaluation.

Threat to external validity (5, p. 40) is strongest in possible interaction of testing and treatment. It was assumed that the experimenter administered the pretests so that pretest sensitization was minimized. To a lesser extent, interaction of selection and treatment as well as reactive arrangements may have affected external validity. Selection could not be controlled so the results of this quasi-experimental study were generalized only to populations similar to the one in this study. It was assumed that reactive arrangements were minimal since the intact class provided a natural setting in which the subjects were not aware that they were being experimentally treated.

Summary

Procedures for the collection of data were presented in Chapter III. Pre-treatment algebra achievement scores, arithmetic scores, and attitude scores were collected from four classes of college algebra students at Louisiana State University in Shreveport. The four treatments administered were homework for one class, weekly quizzing for the second class, four major examinations for the third class, and none of these procedures for the fourth class. All four classes had a teacher-constructed midsemester examination. Scores on a standardized final examination served as the dependent variable.

Instruments used were the Cooperative Mathematics Test, Algebra II; Cooperative Mathematics Test, Arithmetic; Aiker-Dreger Revised Math Attitude Scale; and for the dependent variable, the Cooperative Mathematics Test, Algebra III. These instruments were well documented in the literature with satisfactory validity and reliability.

A quasi-experimental design was selected because randomization could not be completely controlled. This design is commonly used in natural settings and is judged to be a worthwhile design by Campbell and Stanley (14).

CHAPTER BIBLIOGRAPHY

1. Aiken, Lewis R., and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52, No. 1 (February, 1961), 19-24.
2. Borg, Walter R. and Meredith D. Gall, Educational Research, 4th ed., New York, Longman, 1983.
3. Buros, Oscar K., editor, The Seventh Mental Measurements Yearbook, 2, Highland Park, N. J., The Gryphon Press, 1972.
4. Caldwell, James R., "Cooperative Mathematics Test, Algebra III," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 896-897.
5. Campbell, Donald T. and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally College Publishing Company, 1963.
6. Handbook Cooperative Mathematics Tests, Monterey, California, CTB/McGraw-Hill, 1964.
7. Kohler, Emmett T., "The Relationship Between the Cooperative Mathematics Test, Algebra III, ACT Mathematics Usage Test, ACT Composite and Grade Point Average in College Algebra," Educational and Psychological Measurement, 31, No. 4 (Winter, 1973), pp. 929-931.
8. Osborne, Alan R., "Cooperative Mathematics Test, Arithmetic," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 914-915.
9. Shaw, Marvin E. and Jack M. Wright, Scales for the Measurement of Attitudes, New York, McGraw-Hill Publishing Company, 1967.
10. Travers, Kenneth J., "Cooperative Mathematics Test, Algebra II," The Seventh Mental Measurements

Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 894-896.

11. Warrington, Willard G., "Cooperative Mathematics Test, Algebra III," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 897-899.

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

This chapter presents a description of the sample and the findings of the study according to the four null hypotheses. The chapter closes with a summary of the findings of the study.

Description of the Sample

The data were collected from August 25 to December 11, 1986, during the fall semester at Louisiana State University in Shreveport. Four classes of Math 121 (college algebra) were taught by the same teacher using identical procedures in each class, except for the experimental treatment: type of testing strategy.

Pretest instruments were administered to 168 students in the four Math 121 classes; this total was used as the sample for the investigation of attrition rates. There were 118 students left in the four classes at the completion of the study; this total was used as the sample for the investigation of performance in college algebra and posttest attitude toward mathematics.

Demographic data for the subjects of this study were obtained from the demographic data sheet shown in Appendix G. Students were asked to provide information regarding

their major area of study, gender, age, number of years of high school algebra completed, number of years of high school mathematics completed, whether or not they had credit for Math 111 at LSU-S, their ACT score in mathematics, as well as other miscellaneous information.

Of the 168 students involved in the study, 53.6 percent were male, and age ranged from seventeen to fifty-five years with 56 percent in the seventeen to eighteen age group. The number of business majors was larger than the number of science majors by 46 to 34 percent with 20 percent majoring in other academic areas. ACT scores in mathematics as reported by the students showed that 57 percent had scores between 19 and 24. A total of 83 percent of the students indicated that they had two years of high school algebra preparation with 58 percent indicating that they had mathematics courses all four years in high school. Students who did not have two years of high school algebra were advised to take Math 111 (an intermediate algebra prerequisite for the Math 121); respondents indicated that 65 percent had not taken Math 111 at LSU-S.

A specific description of the sample regarding the self reported demographic variables mentioned above separated by homework class, quiz class, control class, and test class can be seen in Table I. This table contains information as reported by a limited portion of the total

TABLE I
DESCRIPTION OF THE SAMPLE

Variable	Homework class		Quiz class		Control class		Test class	
	<u>n</u>	%	<u>n</u>	%	<u>n</u>	%	<u>n</u>	%
Major Area								
Sciences	16	36	8	18	16	41	17	41
Business	16	36	28	64	18	46	16	39
Other	12	28	8	18	5	13	8	20
Gender								
Female	24	55	16	36	17	44	21	51
Male	20	45	28	64	22	56	20	49
Age in years								
17-18 years	26	59	22	51	24	63	18	49
19-22 years	10	23	13	30	13	34	13	35
23-30 years	6	14	6	14	0	0	5	14
30-55 years	2	4	2	5	1	3	1	2
Math 111 credit*								
Yes	20	48	17	39	7	18	13	33
No	22	52	27	61	32	82	26	67
ACT (mathematics)								
< 13	1	4	4	14	1	4	0	0
13-18	10	36	3	11	3	14	4	19
19-24	12	42	14	50	14	64	16	76
> 24	5	18	7	25	4	18	1	5
Years of high school algebra								
0 years	1	3	0	0	1	3	1	3
1 years	5	11	13	30	2	5	5	12
2 years	38	86	31	70	36	92	35	85
Years of high school mathematics								
1 years	1	2	2	4	0	0	0	0
2 years	3	7	6	14	2	5	1	2
3 years	21	47	13	30	10	26	12	30
4 years	20	44	23	52	27	69	27	68

Note. \underline{n} = the number of students in a limited portion of the total sample.

* Math 111 is the intermediate algebra prerequisite course for registration in Math 121 if a student does not have two years of high school algebra.

sample. Analysis of the data indicated that all four classes were predominately composed of seventeen and eighteen year old students who were majoring in business or one of the sciences. The largest difference in gender was in the quiz class with 64 percent males and 36 percent females. A majority of students in each class did not take the preliminary Math 111 intermediate algebra course before entering Math 121. Except for the homework class, a majority of students in each class had a self reported ACT mathematics score of between 19 and 24. The subjects in the four classes reported a range of 44 to 68 percent had mathematics in each of the four high school years with 70 to 92 percent indicating that they had two years of high school algebra.

Findings

To test the hypotheses of this study, pretest measures of attitude towards mathematics, algebra achievement, and arithmetic achievement were collected by administering, respectively, the RMAS, CMTII, and CMTA, to four Math 121 classes at Louisiana State University in Shreveport in the fall semester of 1986. After the experimental treatments were applied, final examination scores for performance and posttest attitude scores were obtained by administering, respectively, the CMTIII and RMAS. All of these scores were converted to percentages for uniformity. Data for

calculation of attrition rates for each class were also collected and left in raw form.

Correlation coefficients were computed for each pair of pretest and criterion variables to determine significant relationships. The effect of testing strategies upon the dependent variables of performance in college algebra and attitude towards mathematics was analyzed using ANCOVA (analysis of covariance) with three covariates. To analyze the effect of testing strategies upon the dependent variable of attrition rate, a test for significance of differences of proportions from four independent samples was used.

Hypothesis 1

The first hypothesis was: There is no significant relationship between the pretest variables:

- (a) algebra achievement,
- (b) attitude towards mathematics, and
- (c) arithmetic achievement,

and each of the criterion variables: performance in college algebra, posttest attitude towards mathematics, and attrition rate;

Pearson product-moment correlation coefficients were computed for performance in college algebra and posttest attitude towards mathematics paired with each pretest variable as shown in Table II. These correlation coefficients were tested for significance at the .05

probability level using a two tailed t test (13; 6, p. 195). All of the correlations were significant. Borg and Gall (2) indicated that correlation coefficients between .20 and .35 show only a slight relationship between the variables although this relationship may be statistically significant. Correlations around .50 are useful when combined with other correlations in a multiple regression equation. "Correlation coefficients ranging from .65 to .80 make possible group predictions that are accurate enough for most purposes" (2, p. 624).

Pretest algebra achievement accounted for 22.6 percent of the variation in posttest performance in college algebra while it accounted for 17.2 percent of the variation in

TABLE II
PEARSON CORRELATION COEFFICIENTS FOR CONTROL
AND CRITERION VARIABLES INCLUDING
t TESTS FOR SIGNIFICANCE

Variables	1	2	3	4	5
1. Algebra achievement	. .	.341*	.442*	.475*	.415*
2. Attitude towards math210*	.413*	.780*
3. Arithmetic achievement422*	.191*
4. Posttest performance470*
5. Posttest attitude

* $p < .05$

N = 118

posttest attitude toward mathematics. Pretest attitude toward mathematics accounted for 17.1 percent and 60.8 percent of the variation in posttest performance in college algebra and attitude toward mathematics, respectively. Pretest achievement in arithmetic accounted for 17.8 percent of the variation in performance in college algebra, but only 3.6 percent of the variation in posttest attitude towards mathematics.

The number of cases in the four experimental groups was 118 (number of students who completed the courses). The critical t for significance at the .05 level was 1.980 for 116 degrees of freedom (6, p. 521). Based on the data obtained, hypothesis 1 regarding the criterion variables of posttest performance and posttest attitude was rejected. There was a significant relationship between the pretest variables and each of the criterion variables: performance in college algebra and attitude towards mathematics.

Point biserial correlation coefficients were computed for each pretest variable paired with the criterion variable of attrition rate as shown in Table III. These correlation coefficients were tested for significance at the .05 probability level using a two tailed t test (13; 6, p. 428). Only pretest algebra achievement was found to be significantly correlated with attrition rate, accounting for almost 10 percent of the variation in dropout rate.

The number of cases in the experimental groups was 168 (number of students who began the courses). The critical t for significance at the .05 level was 1.970 for 166 degrees of freedom. Based on the data obtained, hypothesis 1 regarding attrition rate was rejected only for the (a) part. Both the (b) and (c) parts regarding attrition rate were accepted. There was a significant correlation between algebra achievement and class attrition rate in college algebra. There was no significant correlation between pretest attitude towards mathematics and attrition rate. Likewise, no significant correlation existed between arithmetic achievement and college algebra dropout rate.

TABLE III

PEARSON AND POINT BISERIAL (pbi) CORRELATION COEFFICIENTS
FOR PRETEST VARIABLES AND ATTRITION RATE
INCLUDING t TESTS FOR SIGNIFICANCE

Variables	1	2	3	4
1. Algebra achievement	. .	.312*	.482*	-.309*
2. Attitude towards math212*	-.101
3. Arithmetic achievement	-.130
4. Attrition rate (pbi)

* $p < .05$ N = 168

Hypothesis 2

Hypothesis 2 stated: There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. Hypothesis 2 was the principal hypothesis for this study; hypotheses 3 and 4 were analyzed relative to the outcome of testing for significance of differences among means in hypothesis 2.

It should be noted that hypotheses 3 and 4 were a priori hypotheses intended to test the theoretical framework for this study. Logically, a priori comparisons of the four groups can be applied whether or not the overall statistical test has indicated rejection of the principal null hypothesis (6).

The Dunn-Sidak procedure for testing a priori nonorthogonal contrasts was used to test both hypotheses 3 and 4. Since the treatment levels of this experiment were assigned to intact groups, a special form of the Dunn-Sidak formula for an experimental t statistic was used with the proper covariate adjustments (10, p. 735). The critical t was calculated using three planned a priori contrasts as suggested by Kirk (10, p. 111)) and Winer (14). Two orthogonal comparisons were tested in place of hypothesis 4.

Means and standard deviations were computed for each group and are displayed in Tables IV and V. In Table IV, the symbols X_1 , X_2 , and X_3 represent the control variables of algebra achievement, attitude towards mathematics, and

TABLE IV
MEANS (M) AND STANDARD DEVIATIONS (s)
OF CLASSES ON CONTROL AND
CRITERION VARIABLES

		Homework class N = 37	Quiz class N = 33	Control class N = 26	Test class N = 22	All classes N = 118
X_1	M	41.42	39.92	53.46	48.75	45.02
	s	14.81	14.05	13.73	12.31	14.79
X_2	M	64.18	52.45	62.00	67.64	61.06
	s	17.34	19.32	18.39	19.00	19.08
X_3	M	77.14	77.58	78.00	77.45	77.51
	s	12.32	13.84	9.09	11.96	11.94
Y_1	M	53.78	52.50	60.10	61.93	56.33
	s	14.96	16.90	18.21	17.25	16.93
Y_2	M	57.59	51.14	57.58	57.47	55.76
	s	20.91	19.37	23.21	24.71	21.68

arithmetic achievement, respectively. Y_1 and Y_2 represent the criterion variables of performance in college algebra and posttest attitude towards mathematics, respectively.

An N of 118 was used with the groups ranging in size from 22 to 37 subjects. The descriptive statistics displayed in Table IV pertain to those students in each class who finished the Math 121 course.

Table V contains descriptive statistics regarding the dependent variable of attrition rate. In this case N was

TABLE V
MEANS (M) AND STANDARD DEVIATIONS (s)
OF CLASSES ON PRETEST VARIABLES
AND ATTRITION RATE

		Homework class N = 44	Quiz class N = 44	Control class N = 39	Test class N = 41	All classes N = 168
X ₁	M	41.25	36.99	48.27	42.38	42.04
	s	14.20	14.15	15.13	14.32	14.85
X ₂	M	64.23	52.07	61.63	61.52	59.78
	s	17.64	19.55	19.67	19.79	19.56
X ₃	M	77.55	75.09	77.95	75.22	76.43
	s	11.57	14.18	11.27	13.88	12.77
Z	M	0.159	0.250	0.333	0.463	0.298
	s	0.370	0.438	0.478	0.505	0.459

168, and the means and standard deviations pertain to those students who began the Math 121 course. Z represents the criterion variable of attrition rate, with X₁, X₂, and X₃

representing the three control variables as previously defined.

Classes ranged from 39 to 44 students with dropout rates varying from 15.9 percent to 46.3 percent. The attrition average for all classes was 29.8 percent.

Hypothesis 2 was tested in three distinct parts: hypothesis 2(a), hypothesis 2(b), and hypothesis 2(c). A description of each test of hypothesis follows.

Hypothesis 2(a).--This hypothesis stated that there is no significant difference in performance in college algebra among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. Analysis of covariance (ANCOVA) was used to test for significance of differences in adjusted means in performance in college algebra. Three covariates were used: achievement in algebra (X_1), pretest attitude towards mathematics (X_2), and achievement in arithmetic (X_3) (3; 5, pp. 153-175). ANCOVA is used to control for differences among groups when random control is not feasible nor practical (2, 4).

Homogeneity of regression coefficients, a basic assumption in the analysis of covariance, was tested as a preliminary to using ANCOVA (6, p. 362). The null hypothesis for homogeneity of regression was accepted at the $p = .05$ level. The experimental p for significance was .232 (13).

According to Borg and Gall (2, p. 683), homogeneity of group variances is also a fundamental assumption which must be satisfied to use ANCOVA. Winer (14, p. 208) indicated that the Bartlett test for homogeneity of variance is the most widely used test when unequal groups are present. Homogeneity of variance was tested using a modification of the Bartlett test called the Bartlett-Box F test (13). The null hypothesis was accepted at the $p = .05$ level with an experimental p of .742.

Table VI presents the analysis of covariance computed

TABLE VI

ANALYSIS OF COVARIANCE FOR PERFORMANCE AMONG TESTING STRATEGY CLASSES USING PRETEST ACHIEVEMENT IN ALGEBRA, ATTITUDE TOWARDS MATHEMATICS, AND ACHIEVEMENT IN ARITHMETIC AS COVARIATES

Source	A D J U S T E D			F
	df	SS	MS	
Between	3	374.516	124.839	0.642
Within	111	21583.876	194.449	
Total	114	21958.392		

using the multivariate analysis of variance (MANOVA) statistical procedure contained in the Statistical Package for the Social Sciences, version X, 2nd edition (13).

These results were confirmed using multiple regression

techniques for MANOVA with covariates (8, 9, 11, 12, 13). A critical F statistic of 2.690 was calculated at the $p = .05$ level using 3 and 111 degrees of freedom (6). The experimental F statistic was 0.642 so hypothesis 2(a) was accepted at the .05 level. This F value falls substantially short of unity which is expected under the null hypothesis. The experimental p was .59. There was no significant difference in adjusted group means for performance in college algebra among the four Math 121 classes; because of the small F ratio, it can be concluded that the differences among the unadjusted means were due largely to the effects of the covariates (6, p. 368).

Table VII gives a summary of unadjusted and adjusted means for the criterion variable of performance in college algebra. Means for the control variables of achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic are denoted by X_1 mean, X_2 mean, and X_3 mean, respectively. The adjusted means ranged from a low of 54.174 in the Homework class to a high of 59.355 in the Test class. The unadjusted means differed most by 9.432 percentage points, whereas the largest adjusted mean difference was 5.181 percentage points. The groups were nearly equal in pretest arithmetic achievement, but there were large differences between the largest and smallest means for pretest algebra achievement and attitude towards mathematics.

TABLE VII
SUMMARY OF ADJUSTED MEANS FOR PERFORMANCE
IN COLLEGE ALGEBRA

Group	CONTROL VARIABLES			CRITERION VARIABLE	
	X_1 mean	X_2 mean	X_3 mean	Unadjusted mean	Adjusted mean
Homework class	41.419	64.184	77.135	53.784	54.174
Quiz class	39.924	52.448	77.576	52.500	55.935
Control class	53.462	61.996	78.000	60.096	57.361
Test class	48.750	67.641	77.455	61.932	59.355

Hypothesis 2(b).--This hypothesis stated that there is no significant difference in posttest attitude towards mathematics among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. Analysis of covariance was used to test for significance of differences in adjusted means in posttest attitude towards mathematics. Three covariates were used: achievement in algebra (X_1), pretest attitude towards mathematics (X_2), and achievement in arithmetic (X_3).

As a preliminary to ANCOVA, the null hypotheses regarding homogeneity of regression coefficients and

homogeneity of group variances were tested. Again, the Bartlett-Box F test statistic was used to test for homogeneity of group variances. Both hypotheses were accepted at the .05 probability level with experimental p's of .867 and .605, respectively.

Analysis of covariance was done using MANOVA (13). The results are summarized in Table VIII. A critical F

TABLE VIII

ANALYSIS OF COVARIANCE FOR ATTITUDE AMONG TESTING STRATEGY CLASSES USING PRETEST ACHIEVEMENT IN ALGEBRA, ATTITUDE TOWARDS MATHEMATICS, AND ACHIEVEMENT IN ARITHMETIC AS COVARIATES

Source	A D J U S T E D			F
	df	SS	MS	
Between	3	1179.732	393.244	2.302
Within	111	18965.470	170.860	
Total	114	20145.202		

statistic of 2.690 was calculated using the $p = .05$ level with 3 and 111 degrees of freedom. The experimental F statistic was 2.302, so hypothesis 2(b) was accepted at the .05 level. The experimental p was .081. There was no significant difference in adjusted group means for posttest attitude towards mathematics among the four Math 121

classes; any differences among the unadjusted means were likely due to the effects of the covariates.

Table IX gives a summary of the unadjusted and adjusted means for the criterion variable of posttest attitude

TABLE IX
SUMMARY OF ADJUSTED MEANS FOR ATTITUDE
TOWARDS MATHEMATICS

Group	CONTROL VARIABLES			CRITERION VARIABLE	
	X_1 mean	X_2 mean	X_3 mean	Unadjusted mean	Adjusted mean
Homework class	41.419	64.184	77.135	57.592	56.070
Quiz class	39.924	52.448	77.576	51.139	60.282
Control class	53.462	61.996	78.000	57.577	53.997
Test class	48.750	67.641	77.455	57.468	50.543

towards mathematics. Means for the control variables of achievement in algebra, pretest attitude towards mathematics and achievement in arithmetic are denoted by X_1 mean, X_2 mean, and X_3 mean, respectively. The adjusted means ranged from a low of 50.543 in the Test class to a high of 60.282 in the Quiz class. The unadjusted means differed most by 6.453 percentage points, whereas the largest adjusted mean difference was 9.739. It should be

noted that the unadjusted means were nearly equal except for the Quiz class. Thus each unadjusted mean differed substantially from the Quiz class mean, but upon adjustment, adjacent means differed more uniformly.

Hypothesis 2(c).--This hypothesis stated that there is no significant difference in attrition rate among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. There were 168 students who began the four classes exposed to the different testing strategies. As shown in Table X, the class sizes ranged from 39 subjects in the Control class and 41 subjects in

TABLE X
OBSERVED FREQUENCIES FOR CLASS
ATTRITION RATE

Response	Testing Strategy				Total frequencies
	Homework class	Quiz class	Control class	Test class	
Finished course	37	33	26	22	118
Dropped course	7	11	13	19	50
Total frequencies	44	44	39	41	168

the Test class, to 44 subjects in each of the Homework and Quiz classes. Table X also displays the frequency counts for those students who finished or dropped their Math 121

class. Only 7 out of 44 (15.9 %) students dropped out of the Homework class, while 19 of the 41 (46.3 %) members of the Test class dropped out. The overall attrition rate was 29.8 percent.

A test for the significance of differences of proportions from four independent samples was used to test hypothesis 2(c). Black and Brookshire (1, p. 10) interpret the null hypothesis as a statement ". . . that the proportions of the populations that the samples come from are equal." The test used was an extension of Ferguson's test for a significant difference between two independent proportions (6, pp. 185-187; 1, pp. 10-14).

Table XI contains the theoretical expected frequency

TABLE XI
EXPECTED FREQUENCIES FOR CLASS
ATTRITION RATE

Response	Testing Strategy				Total frequencies
	Homework class	Quiz class	Control class	Test class	
Finished course	30.9	30.9	27.4	28.8	118
Dropped course	13.1	13.1	11.6	12.2	50
Total frequencies	44	44	39	41	168

counts for those students who finished or dropped their

Math 121 class. Each cell frequency was calculated by multiplying a column total by a row total and dividing by the total $N = 168$. For example, those students in the Homework class who dropped their Math 121 class before the final examination had a 13.1 percent expected attrition rate. This expected attrition rate was computed by multiplying 44 by 50 and dividing by 168. The theoretical frequencies in Table XI are those expected if testing strategy type is truly independent of attrition rate (6).

Table XII summarizes the calculations necessary to

TABLE XII

CHI-SQUARE TEST OF SIGNIFICANCE FOR DIFFERENCES
OF ATTRITION RATES AMONG TESTING
STRATEGY GROUPS

CLASS	DECISION	observed (O)	expected (E)	$(O - E)^2$	$\frac{(O - E)^2}{E}$
Homework	Stayed	37	30.9	37.21	1.204
	Dropped	7	13.1	37.21	2.840
Quiz	Stayed	33	30.9	4.41	0.143
	Dropped	11	13.1	4.41	0.337
Control	Stayed	26	27.4	1.96	0.072
	Dropped	13	11.6	1.96	0.169
Test	Stayed	22	28.8	46.24	1.606
	Dropped	19	12.2	46.24	3.790

* $p < .05$

Chi-Sq = 10.161*

compute a Chi-square statistic from the frequencies in Tables X and XI. The degrees of freedom were 3 (number of experimental groups minus one) and the significance level was $p = .05$. A critical Chi-square of 7.82 (6, p. 522) was compared with the experimental value of 10.161. The experimental p was .018, so hypothesis 2(c) was rejected at the .05 alpha level. There was a significant difference in attrition rate among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

After a significant test for differences among several groups, post hoc multiple comparisons were appropriate (1, 7, 10). Table XIII presents a summary of all pairwise

TABLE XIII
A POSTERIORI PAIRWISE COMPARISONS USING A
POST HOC SCHEFFE PROCEDURE TO DETECT
DIFFERENCES IN ATTRITION RATES

	1	2	3	4
1. Homework class	. .	1.13	3.47	10.17*
2. Quiz class	0.70	4.41
3. Control class	1.44
4. Test class

* $p < .05$

comparisons. As in the analysis of variance, multiple comparisons can be done to determine where significant

differences exist (10, 14). In this case there were four groups and the scores were group proportions and not group means. Black and Brookshire (1, pp. 14-16) outlined Scheffe's post hoc procedures for the K-sample problem with independent proportions. For $K = 4$, Table XIII summarizes the pairwise comparisons of group proportions interpreted as attrition rates. The body of this table contains the experimental Chi-square statistics as calculated according to Black and Brookshire (1). The critical Chi-square for 3 degrees of freedom (number of groups minus one) and an alpha level of $p = .05$ was 7.82 (6, p. 522). The only Chi-square larger than 7.82 was 10.17, calculated from comparing the Homework class and Test class. The corresponding experimental p value for this comparison was .018. Therefore, there was a significant difference in attrition rate between the Homework class and the Test class. A contingency coefficient was computed to be 0.33. According to Ferguson (6, p. 214), this descriptive statistic is analogous to a correlation coefficient and can be used to compute the degree of association between two categorical variables. Squaring 0.33 gave 0.1069 which was interpreted to mean that 10.69 percent of the variation in attrition rate between the Homework class (15.9%) and Test class (46.3%) was attributable to the type of testing strategy used, i.e., homework or tests.

All other pairwise comparisons between class attrition rates had Chi-squares less than the critical value of 7.82. Thus, there were no other significant differences among groups relative to attrition rate. The overall significant Chi-square arrived at in testing hypothesis 2(c) was at least partially caused by a significant difference in the mean attrition rates of the Homework and Test classes.

Hypothesis 3

Hypothesis 3 stated: There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

between the two classes using different types of frequent testing: Quiz class and Homework class. This hypothesis was tested using results from testing hypothesis 2 as well as a priori hypothesis testing procedures. Hypothesis 3 was tested in three distinct parts: hypothesis 3(a), hypothesis 3(b), and hypothesis 3(c).

Hypothesis 3(a).--This hypothesis stated that there is no significant difference in performance in college algebra between the two classes using different types of frequent testing: Quiz class and Homework class. The Dunn-Sidak a priori test for nonorthogonal contrasts (10, p. 740) was used to test hypothesis 3(a) in conjunction

with hypothesis 4(a). There were three a priori contrasts in all, so the critical t test statistic was calculated to be 2.427 (10, p. 845) for a significant probability level of .05 and 111 degrees. The experimental t was 0.513 for the contrast stated in hypothesis 3(a). This hypothesis was accepted, so there was no significant difference in adjusted mean performance in college algebra between the Quiz class and the Homework class.

Hypothesis 3(b).--This hypothesis stated that there is no significant difference in posttest attitude towards mathematics between the two classes using different types of frequent testing: Quiz class and Homework class. There were three a priori contrasts in all, so the critical t test statistic was calculated to be 2.427 (10, p. 845) for a significant probability level of .05 and 111 degrees. The experimental t was 1.307 for the contrast stated in hypothesis 3(b). This hypothesis was accepted, so there was no significant difference in adjusted mean posttest attitude towards mathematics between the Quiz class and the Homework class.

Hypothesis 3(c).--This hypothesis stated that there is no significant difference in attrition rate between the two classes using different types of frequent testing: Quiz class and Homework class. The overall Chi-square test for significance of differences of proportions from four

independent samples was significant at the .05 probability level. Multiple comparisons done in the analysis of hypothesis 2(c) showed that for the pairwise comparison, Homework class versus Quiz class, the experimental Chi-square was 1.13. Upon comparison with the critical Chi-square of 7.82, the Homework class attrition rate was not significantly different from the Quiz class attrition rate at the .05 probability level (see Table XIII). Hypothesis 3(c) was accepted at the .05 level. There was no significant difference in attrition rate between the Quiz class and the Homework class at the .05 level.

Hypothesis 4

Hypothesis 4 stated: There is no significant difference

- (a) in performance in college algebra,
- (b) in posttest attitude towards mathematics, and
- (c) in attrition rate

among the groups which are tested in-class with different frequencies: Quiz class, Test class, and Control class. This hypothesis was tested using results from testing hypothesis 2 as well as a priori hypothesis testing procedures. Hypothesis 4 was tested in three distinct parts: hypothesis 4(a), hypothesis 4(b), and hypothesis 4(c).

Hypothesis 4(a).--This hypothesis stated that there is no significant difference in performance in college algebra among the groups which are tested in-class with different frequencies: Quiz class, Test class, and Control class. The Dunn-Sidak a priori test for nonorthogonal contrasts (10, p. 740) was used to test hypothesis 4(a) in conjunction with hypothesis 3(a). There were three a priori contrasts in all, so the critical t test statistic was calculated to be 2.427 (10, p. 845) at a significant probability level of .05 and 111 degrees. As proposed by Winer (14, pp. 256-260), hypothesis 4(a) was equivalently tested by simultaneously testing two hypothesis for orthogonal contrasts. They stated: (1) there is no significant difference in adjusted means for performance in college algebra between the Quiz class and the Control class, and (2) there is no significant difference in performance in college algebra between the Test class adjusted mean and the average of Quiz and Control class adjusted means.

The first hypothesis involved a pairwise comparison which had an experimental t test statistic computed to be 0.365. Upon comparison with the critical t of 2.427, the Dunn-Sidak t test led to accepting this hypothesis at the .05 level. The second hypothesis involved a contrast with an experimental Dunn-Sidak t test statistic of 1.096. This hypothesis was also accepted at the .05 level. Therefore,

the experimental data did not reject hypothesis 4(a) at the .05 level; there was no significant difference in the adjusted means for performance in college algebra among the Quiz class, Test class, and Control classes.

Hypothesis 4(b).--This hypothesis stated that there is no significant difference in posttest attitude towards mathematics among the groups which are tested in-class with different frequencies: Quiz class, Test class, and Control class. The Dunn-Sidak a priori test for nonorthogonal contrasts (10, p. 740) was used to test hypothesis 4(b) in conjunction with hypothesis 3(b). There were three a priori contrasts in all, so the critical t test statistic was calculated to be 2.427 (10, p. 845) at a significant probability level of .05 and 111 degrees. Due to Winer (14, pp. 256-260), hypothesis 4(b) was equivalently tested by simultaneously testing two hypothesis for orthogonal contrasts. They stated: (1) there is no significant difference in adjusted means for posttest attitude towards mathematics between the Quiz class and the Control class, and (2) there is no significant difference in posttest attitude towards mathematics between the Test class adjusted mean and the average of Quiz and Control class adjusted means.

The first hypothesis involved a pairwise comparison which had an experimental t test statistic computed to be

1.718. Upon comparison with the critical t of 2.427, the Dunn-Sidak t test led to accepting this hypothesis at the .05 level. The second hypothesis involved a contrast with an experimental Dunn-Sidak t value of 2.850. The experimental p was estimated at .02 (10, p. 845) using linear interpolation. This hypothesis was not accepted at the .05 level. Therefore, the experimental data rejected hypothesis 4(b) at the .05 level; there was a significant difference in the adjusted means for posttest attitude towards mathematics among the Quiz class, Test class, and Control classes. A posteriori tests were not performed to determine if any particular pair of means were significantly different.

Hypothesis 4(c).--This hypothesis stated that there is no significant difference in attrition rate among the groups which are tested in-class with different frequencies: Quiz class, Test class, and Control class. The overall Chi-square test of significance for differences of proportions from four independent samples was significant at the .05 probability level. Pairwise comparisons done in the analysis of hypothesis 2(c) showed that for the three classes investigated in hypothesis 4(c), a comparison of the maximum attrition rate (0.463 for the Test class) with the minimum attrition rate (0.25 for the Quiz class) yielded an experimental Chi-square of 4.41.

Upon comparison with the critical Chi-square of 7.82, the maximum and minimum proportions were not significantly different at the .05 probability level. Table XIII indicates that no other pairwise comparisons among the Quiz, Test, and Control classes were significant. Hypothesis 4(c) was retained at the .05 level as dictated by the post hoc procedures formulated from the conservative Scheffe test for comparisons of means (1). There was no significant difference in attrition rate among the Quiz class, Test class, and Control class.

Additional Findings

The four Math 121 classes were asked to fill out an opinionnaire during their final examination period (see Appendix H). There were two questions asked relative to the students' preference for a testing strategy as defined in this study.

The first question asked which of the four testing strategies: homework, quiz, test, or control, the student preferred. The students in the Homework class chose homework 46.0 percent of the time. Likewise, 36.4 percent of the Quiz class students chose the strategy used in their class. The Test class preferred to have homework at a 63.6 percent rate, while 42.3 percent of the Control class picked the quiz method. Combining the four classes showed that 42.4 percent of the 118 students preferred to hand in

homework twice a week for 50 percent of their grade. The test method was chosen by 33.9 percent with 19.5 percent choosing quizzes; just 4.2 percent of the students wanted a midsemester and final examination only.

Question number two asked which of the four testing strategies, or combinations of them, the student preferred. The homework and test strategy combination was picked most by each of the four classes in this study: Homework class (56.8%), Quiz class (27.3%), Test class (59.1%), and Control class (23.1%). The Control class also chose the single testing strategy at a 23.1 percent rate. Combining the four classes showed that 41.5 percent of the 118 students preferred to hand in homework and take tests regularly. This choice was favored by almost three to one over the second choice (14.4%): quizzes and homework combined.

Summary of Findings

The results of the study are summarized in the following statements:

1. There was a significant correlation between each of the pretest variables and the criterion variable of performance in college algebra. The pretest variables were achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic.

2. There was a significant correlation between each of the pretest variables and the criterion variable of posttest attitude towards mathematics. The pretest variables were achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic.

3. There was a significant correlation between achievement in algebra and attrition rate in a college algebra class.

4. The correlation coefficient between pretest attitude towards mathematics and attrition rate was not significant.

5. The correlation coefficient between achievement in arithmetic and attrition rate was not significant.

6. There was no significant difference in adjusted group means for performance in college algebra among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

7. There was no significant difference in adjusted group means for posttest attitude towards mathematics among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

8. There was a significant difference in attrition rate among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

9. There was a significant difference in attrition rate between the Homework class and Test class.

10. There was no significant difference in attrition rate between the Homework class and Control class.

11. There was no significant difference in attrition rate between the Quiz class and Control class.

12. There was no significant difference in attrition rate between the Quiz class and Test class.

13. There was no significant difference in attrition rate between the Control class and Test class.

14. There was no significant difference in adjusted mean performance in college algebra between the two classes which used different types of frequent testing: Quiz class and Homework class.

15. There was no significant difference in adjusted mean posttest attitude towards mathematics between the two classes which used different types of frequent testing: Quiz class and Homework class.

16. There was no significant difference in attrition rate between the two classes which used different types of frequent testing: Quiz class and Homework class.

17. There was no significant difference in adjusted mean performance in college algebra among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

18. There was a significant difference in adjusted mean posttest attitude towards mathematics among the groups

which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

19. There was no significant difference in attrition rate among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

20. There were 53.6 percent males and 46.4 percent females out of 168 student participating in this study.

21. The "typical" student in this study was a business major between seventeen and eighteen years of age who had an ACT score of between 19 and 24, and had two years of high school algebra preparation.

22. When given a choice from among the four testing strategies defined in this study, 42.4 percent of the 118 student subjects said they would prefer to hand in homework as their method of testing. The test method was chosen by 33.9 percent.

23. When given a choice from among the four testing strategies, or combinations of them, 41.5 percent of the 118 student subjects said they would prefer the combination of homework and test. This was almost three to one over the second choice: homework and quizzes combined which was chosen by 14.4 percent.

CHAPTER BIBLIOGRAPHY

1. Black, Ken and William K. Brookshire, "Hypothesis Testing: Proportions," unpublished paper presented to Dr. Curry, EDER 625, North Texas State University, Denton, (January, 1979), 10-16.
2. Borg, Walter R. and Meredith D. Gall, Educational Research, 4th ed., New York, Longman, 1983.
3. Brookshire, William K., SPSS: Printouts of Illustrative Examples and Exercises from Ferguson's 5th Edition, Denton, North Texas State University, 1984.
4. Campbell, Donald T. and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally College Publishing Company, 1963.
5. Cook, Thomas D. and Donald T. Campbell, Quasi-Experimentation Design & Analysis Issues for Field Settings, Boston, Houghton Mifflin Company, 1979.
6. Ferguson, George A., Statistical Analysis in Psychology and Education, 5th ed., New York, McGraw-Hill Book Company, 1981.
7. Huck, Schuyler W., William H. Cormier, and William G. Bounds, Jr., Reading Statistics and Research, New York, Harper & Row, 1974.
8. Kerlinger, Fred N. and Elazar J. Pedhazur, Multiple Regression in Behavioral Research, New York, Holt Rinehart and Windston, Inc., 1973.
9. Kleinbaum, David G. and Lawrence L. Kupper, Applied Regression Analysis and Other Multivariable Methods, North Scituate, Massachusetts, Duxbury Press, 1978.
10. Kirk, Roger E., Experimental Design: Procedures for the Behavioral Sciences, 2nd ed., Belmont, California, Brooks/Cole Publishing Company, 1982.
11. Norsusis, Marija J., SPSS^x Introductory Statistics Guide, New York, McGraw-Hill Book Company, 1983.

12. _____, SPSS^x Advanced Statistics Guide,
New York, McGraw-Hill Book Company, 1985.
13. SPSS^x User's Guide, 2nd ed., New York, McGraw-Hill
Book Company, 1986.
14. Winer, B. J., Statistical Principles in Experimental
Design, New York, McGraw-Hill Book Company, 1971.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The final chapter of this study is comprised of a summary of the study and a discussion of the findings. The chapter also includes a discussion of conclusions with implications and lists recommendations for further study.

Summary

The problem of this study was the association between testing strategies and performance in college algebra, attitude towards mathematics, and attrition rate. E. L. Thorndike's (45, 46, 47) distribution of practice theory as related to frequency of testing, and Kurt Lewin's (33) field theory applied to student tension formed the theoretical framework for this study. The sample to test the hypothesis regarding attrition rate consisted of 168 students. Of the 168 students, 118 took a final examination and comprised the sample to test the hypothesis regarding performance in college algebra and attitude towards mathematics. The subjects were distributed among four intact Math 121 college algebra classes taught at Louisiana State University in Shreveport in the fall semester of 1986. The purposes of the study were

1. to determine the effects of four testing strategies

upon performance in college algebra, attitude towards mathematics, and attrition rate;

2. to determine the effects of two types of frequent testing upon performance in college algebra, attitude towards mathematics, and attrition rate;

3. to determine the effects of different frequencies of in-class testing upon performance in college algebra, attitude towards mathematics, and attrition rate; and

4. to draw conclusions which might serve as a basis for selecting testing methods for college algebra classes.

A survey of related literature indicated a need for updating, refining, and extending research dealing with frequency of testing and retention in an educational environment. Relatively few studies have been done involving college algebra students who are exposed to varying testing strategies such as required homework, frequent quizzing, less frequent unit exams, and no required work or testing prior to midsemester and final examinations. Available research is inconclusive about performance in mathematics as a function of testing strategy (22, 24, 48), and the literature is mixed on whether or not attitude towards mathematics is related to testing strategy (1, 7, 38). Most literature evidence associated with retention in college classes deals with "dropout counts," or with identifying personological variables which affect attrition rates (8, 17, 19).

Because intact college algebra classes were used in this study, pretest data were collected to use in an analysis of covariance. The instruments used were

1. The Aiken-Dreger Revised Math Attitude Scale (RMAS) to measure pre-treatment and post-treatment attitude towards mathematics (1),
2. The Cooperative Mathematics Test, Algebra II (CMTII) to measure pre-treatment algebra achievement (25),
3. The Cooperative Mathematics Test, Arithmetic (CMTA) to measure pre-treatment arithmetic achievement (25), and
4. The Cooperative Mathematics Test, Algebra III (CMTIII) to measure performance in college algebra (25).

Demographic and mathematical preparation data were collected and analyzed to form a research profile for the student subjects in this study. An opinionnaire was given to provide data for determining testing strategy preferences of the subjects. These data were analyzed using ranges, frequencies, and percentages.

Three statistical tests for significance were used to analyze the hypotheses of the study. Analysis of covariance (ANCOVA) was used with three covariates: achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic (12, 42) to analyze the data related to performance in college algebra and posttest attitude towards mathematics. The Dunn-Sidak a priori procedure was used to check for significance among

particular subsets of means (32, 51). A test for the significance of differences of proportions from four independent samples was used to analyze the data related to attrition rate (10).

The results of the study are summarized in the following statements:

1. There was a significant correlation between each of the pretest variables and the criterion variable of performance in college algebra. The pretest variables were achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic.

2. There was a significant correlation between each of the pretest variables and the criterion variable of posttest attitude towards mathematics. The pretest variables were achievement in algebra, pretest attitude towards mathematics, and achievement in arithmetic.

3. There was a significant correlation between achievement in algebra and attrition rate in a college algebra class.

4. The correlation coefficient between pretest attitude towards mathematics and attrition rate was not significant.

5. The correlation coefficient between achievement in arithmetic and attrition rate was not significant.

6. There was no significant difference in adjusted group means for performance in college algebra among the

four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

7. There was no significant difference in adjusted group means for posttest attitude towards mathematics among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

8. There was a significant difference in attrition rate among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class.

9. There was a significant difference in attrition rate between the Homework class and Test class.

10. There was no significant difference in attrition rate between the Homework class and Control class.

11. There was no significant difference in attrition rate between the Quiz class and Control class.

12. There was no significant difference in attrition rate between the Quiz class and Test class.

13. There was no significant difference in attrition rate between the Control class and Test class.

14. There was no significant difference in adjusted mean performance in college algebra between the two classes which used different types of frequent testing: Quiz class and Homework class.

15. There was no significant difference in adjusted mean posttest attitude towards mathematics between the two

classes which used different types of frequent testing:

Quiz class and Homework class.

16. There was no significant difference in attrition rate between the two classes which used different types of frequent testing: Quiz class and Homework class.

17. There was no significant difference in adjusted mean performance in college algebra among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

18. There was a significant difference in adjusted mean posttest attitude towards mathematics among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

19. There was no significant difference in attrition rate among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class.

20. Of the 168 students participating in the study, 53.6 percent were males and 46.4 percent were females.

21. The "typical" student in this study was a business major between seventeen and eighteen years of age who had an ACT score of between 19 and 24, and had two years of high school algebra preparation.

22. When given a choice from among the four testing strategies (homework, quiz, test, control), 42.4 percent of the 118 student subjects who completed the study said they

would prefer to hand in homework as their method of testing. The test method was chosen by 33.9 percent.

23. When given a choice from among the four testing strategies, or combinations of those strategies, 41.5 percent of the 118 student subjects said they would prefer the combination of homework and test. This was almost three to one over the second choice: homework and quizzes combined which was chosen by 14.4 percent.

Discussion of the Findings

Hypotheses

There were four hypotheses in the study; the principal hypothesis was 2 with hypotheses 3 and 4 related directly to the theoretical framework of the study. Hypotheses 2, 3, and 4 each were subdivided into parts (a), (b), and (c). A test of hypothesis 1 indicated associations between variables which were used in hypothesis 2. A discussion of the hypotheses follows.

Hypothesis 1.--There was a significant correlation between each of the pretest variables and the criterion variables of performance in college algebra and posttest attitude towards mathematics. The pretest variables were achievement in algebra, attitude towards mathematics, and achievement in arithmetic. This hypothesis was tested to check the relationships between variables needed for the ANCOVA used in hypotheses 2, 3, and 4.

Campbell and Stanley (12) indicate that a significant correlation should exist between a pretest variable and a criterion variable for the pretest variable to be used as a covariate in an ANCOVA. Also, if several variables are used as covariates, they should be relatively uncorrelated. The correlations between pretest variables and criterion variables ranged from .191 to .780 for arithmetic achievement paired with posttest attitude and pretest attitude paired with posttest attitude, respectively. These correlations were significant at the .05 level as expected by the researcher. Correlations between the three possible pairings of pretest variables were .210, .341, and .442. Using a two tailed t test, these correlations were significant at the .05 level. The strongest relationship was between algebra achievement and arithmetic achievement at .442. Although these correlations were significant, they were relatively low, so the pretest variables were considered unrelated for ANCOVA purposes. Borg and Gall (11) point out that correlations below .50 show only slight relationship between the variables even though they may be statistically significant. Correlations around .50 are more useful, while correlations in the .65 to .80 range make possible group predictions. Because the researcher chose the pretest variables before the study began, and because the correlations were as expected, it was decided

to use all three pretest variables as covariates in testing hypotheses 2, 3, and 4.

Regarding the last part of hypothesis 1, there was a significant correlation between the pretest variable of achievement in algebra and the criterion of attrition rate. But there was no significant correlation between each of the other pretest variables (pretest attitude and achievement in arithmetic) and attrition rate. ANCOVA was not done relative to the criterion of attrition rate, so these correlations were used only for relationship observations. The main observation was that the correlation of $-.309$ between achievement in algebra and attrition rate showed an inverse relationship with 9.5 percent of the variation in one variable accounted for by the variation in the other variable (21).

Hypothesis 2(a).--There was no significant difference in adjusted group means for performance in college algebra among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. The ANCOVA experimental F statistic was $.642$ with $p = .59$ indicating that the differences in unadjusted means for performance in college algebra were due mainly to the effects of the covariates (21). Pretest achievement in arithmetic was nearly equal among classes, but the pretest variables of achievement in algebra and attitude towards mathematics had noticeable variations in means among the four groups.

The adjusted means were statistically equal at the .05 level of significance, but the unadjusted means ranged from 52.5 percent in the Quiz class to 61.9 percent in the Test class. Performance in college algebra appears to depend more on the pretest variables than on the type of testing strategy used in class. This result was not expected by the researcher, and seems to refute the study by Townsend and Wheatley (48) which indicated that a delay in giving and returning tests (feedback) for some optimum amount of time increased performance. The distribution of practice principle set forth by Thorndike (45, 46, 47) and extended by Ammons (5) was not supported due to acceptance of hypothesis 2(a).

According to Ferguson (21), since there was no significant difference in the adjusted means for performance in college algebra, the variation in unadjusted means can be attributed to some extent to the covariates. The affect of achievement in algebra on final performance in college algebra was expected by the researcher because of the close association. The effect of the covariate, attitude towards mathematics, on performance in college algebra supports one of Thorndike's subsidiary laws of connectionism related to human learning (45): the Set or Attitude law which was the second of his five subordinate laws. It proclaimed that an organism is guided in its learning by its "set" or total attitude. Applied to this study, a more positive attitude

towards mathematics did correspond to higher unadjusted and adjusted final examination mean scores: the Test class had the highest scores in both pretest attitude and performance.

Testing hypothesis 2(a) was consistent with the plea by Behrman, Dark, and Paul (9) for investigations which might help clarify the factors necessary for increased performance in academics. There is a need for a testing strategy (16, 52) in college algebra classes, but apparently it makes no difference relative to performance on a final examination what type of strategy is used. Giving required homework, several short weekly quizzes, regular chapter tests, or just a midsemester and final examination are equally effective statistically.

Hypothesis 2(b).--There was no significant difference in adjusted group means for posttest attitude towards mathematics among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. The ANCOVA experimental F statistic was 2.302 with $p = .081$ indicating that the test was close to significance at the .05 level. But hypothesis 2(b) was accepted at the .05 level, with the observation that the adjusted means for posttest attitude towards mathematics were larger for the Quiz class (60.282) and Homework class (56.070) than for the Control class (53.997) and Test class (50.543). Acceptance of hypothesis 2(b) in this context indicated that most of the fluctuation in the unadjusted means was

due to the effects of the covariates, but the effect of the testing strategy treatment should not be totally discounted. The unadjusted mean percents for posttest attitude toward mathematics were nearly equal for all the groups (57.59, 57.58, and 57.47) except the Quiz group which recorded a lower mean of 51.14. The covariate means were the same as in hypothesis 2(a) discussion where achievement in algebra and pretest attitude towards mathematics had large mean differences, but achievement in arithmetic was nearly equal for the four groups. The adjusted means for posttest attitude towards mathematics were considered statistically equal at the .05 significance level. The unadjusted Quiz class percent mean differed from each of the other class means by a little more than 6 percent. Attitude towards mathematics appears to depend more on the pretest variables than on the type of testing strategy used in class. It should be noted that the quiz strategy of testing appears to cause a higher final adjusted mean attitude towards mathematics than any of the other testing strategies investigated in this study. These results were expected by the researcher except for the slight tendency for the quiz strategy to make mathematics attitude more positive. Aiken and Dreger (1) did extensive research on associations between mathematics attitude and Differential Aptitude Tests (DAT) (both verbal and

numerical). Significant association between mathematics attitude and achievement in mathematics for females was discovered, but not for males. Later studies by Aiken (2, 3, 4) indicated that direct experiences in relation to college mathematics contribute to positive mathematics attitudes were not supported; in particular, Aiken found that certain traditional practices such as homework tend to create positive attitudes toward mathematics. To some extent, the tendency for the adjusted quiz strategy mean to make final attitudes more positive supports some of Aiken's later work. Anttonen's (7) work with longitudinal relationships between mathematics attitudes and achievement in general was not supported relative to mathematics attitudes. Accepting hypothesis 2(b) showed that the concept of testing strategy in a college algebra classroom made no significant difference relative to final attitudes of students towards mathematics.

Hypothesis 2(c).--There was a significant difference in attrition rate among the four testing strategy groups: Quiz class, Homework class, Test class, and Control class. The statistical test performed was a Chi-square for the significance of differences in proportions from four independent groups as recommended by Black and Brookshire (10). There were 168 students participating in the four classes which ranged in size from 39 to 44 students. An experimental Chi-square of 10.161 with a $p = .018$ indicated

that the attrition rates differed significantly due to the type of testing strategy used in the college algebra class. This result was expected by the researcher; it supports Cope and Hewitt (14) in their belief that the dropout phenomenon is a complex series of interactions between the student and the educational environment. Most of the research done related to the attrition-retention problems in colleges and universities involves identifying personal factors which appear to cause students to drop out of class or school. Astin (8) indicated that there is a need to define the causes of high attrition among college students. This study supports Astin, as well as Cope and Hewitt's (15) factor analysis of self-reported problems accounting for dropping out of college. The fact that testing strategies significantly affect attrition rate appears to be a unique contribution to existing literature related to causes of high attrition rate among college algebra students.

Post hoc pairwise comparisons (10) were performed to discover which pairs of testing strategies differed significantly. No comparisons were significant except for the Homework class paired with the Test class. The Homework class had an attrition rate of 15.9 percent while the Test class had a rate of 46.3 percent. Apparently, using the testing strategy of required homework serves to keep students in a college algebra class, while the pressure of major examinations tends to cause dropouts.

Previous results in this study showed that homework was no better or worse than other testing strategies with respect to performance on a final examination or final attitude towards mathematics, so it seems that using the homework method would benefit everyone at least in the context of retention.

Hypothesis 3(a).--There was no significant difference in adjusted mean performance in college algebra between the two classes which used different types of frequent testing: Quiz class and Homework class. The Dunn-Sidak a priori procedure for testing hypotheses produced a t statistic value of .513. No significance at the .05 level was found when this was compared to the critical t value of 2.427. The Homework class and Quiz class were statistically equal at the .05 significance level relative to final examination performance in college algebra. This result was not expected by the researcher, and Kurt Lewin's field theory (18, 33) in the context of tension was not supported. According to Lewin's theory, the Quiz class should have produced the tension necessary to make these students perform better than the lower tensioned Homework class. This result does not support the studies done by Anderson (6) and others done before 1950 (43) in which homework was favorable in affecting performance in mathematics classes.

Schmidt (40) performed a 1973 experiment entirely consistent with the results of hypothesis 3(a). Schmidt's

study was nearly identical to the present study except he used calculus II students and two original groups: those who had quizzes and no homework and those who had homework and no quizzes. His study also differed in that he equated his groups statistically by using the covariates: ACT score, calculus I grade, and pretest attitude. No statistically significant difference in adjusted mean achievement of the two groups occurred. Cartledge and Sasser's study (13) in 1981 was not supported by the present study. They obtained significant results at the .01 level when comparing two algebra classes: homework and no homework on the criterion variable of mathematics achievement. Their study involved class sizes of 15 students as opposed to the present study in which class sizes were 37 and 33.

In a study involving large numbers of subjects, Mason (35) had two groups: a required homework group with 241 students and a non-homework group with 191 students. The present study supports Mason's results that there was no significant difference in mathematics achievement between the required homework group and the non-homework group. The present study differed from the Mason study where several teachers were used with each teacher conducting a homework and a non-homework class. Mason's results were found by averaging over all teachers, and his conclusion

was that each teacher should determine which of the two methods to use to be most effective.

Other related studies supported by the present research were done by Maertens (34) and Taylor (44). Maertens discovered that homework had no significant effect upon arithmetic achievement as measured by tests of knowledge of arithmetic processes, computational skill, and problem solving ability. His groups were equated statistically relative to intelligence. Taylor compared the effects of two testing strategies on the achievement of Algebra I and Geometry I students. The study lasted eighteen weeks and showed that a compulsory homework approach was not significantly different from a non-compulsory approach relative to achievement scores. Another study supported by this research was Hansen's (26) research at a public two-year college in California where three mathematics classes were divided into experimental and control groups. A trigonometry and two calculus classes were used with the experimental groups receiving required homework assignments while the control group did not turn in homework. After eight weeks, no significant difference occurred between the adjusted means of the posttest scores of the two groups.

Only two studies were located which directly compared homework as a testing strategy with frequent testing. In both cases (36, 40) no significant difference in mean performance was recorded in support of the current study.

Hypothesis 3(b).--There was no significant difference in adjusted mean posttest attitude towards mathematics between the two classes which used different types of frequent testing: Quiz class and Homework class. The Dunn-Sidak experimental t value of 1.307 was found to be less than the critical t value of 2.427. Thus the Homework class and Quiz class were statistically equal at the .05 significance level relative to posttest attitude towards mathematics in a college algebra class. This result was expected by the researcher. But it was not expected that the Quiz class adjusted mean (60.28) would exceed the Homework class adjusted mean (56.07). The extra tension produced by in-class testing was expected to make the students' attitude more negative than the attitude of students in the Homework class.

Schmidt's study (40) in 1973 also investigated attitude as a dependent variable. His results were supported by the present research. He found no significant difference in posttest attitude towards mathematics when comparing calculus II students in homework-no quiz and quiz-no homework groups. Similarly, Maertens 1968 study involving 342 students was supported by this study since no effect of homework upon attitudes was found. Parrish (39) did research in 1976 which concluded that there was no significant difference in attitude towards mathematics between classes having homework and those not having

homework. Aiken (1) published research which is not supported by the present study. He showed, in several detailed studies (2, 3, 4), that homework affects attitude towards mathematics positively.

Hypothesis 3(c).--There was no significant difference in attrition rate between the two classes which used different types of frequent testing: Quiz class and Homework class. The overall Chi-square test for differences among the four testing strategy groups was significant at the .05 level, but this pairwise comparison was not significant. It was expected that the Quiz class would have a significantly higher attrition rate. The Quiz class had an attrition rate of 25.0 percent; the Homework class had a rate of 15.9 percent. Although the difference in attrition rates was not significant, it should be noted that the Homework class had the lower attrition rate as expected.

Hypothesis 4(a).--There was no significant difference in adjusted mean performance in college algebra among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class. This result was obtained by using the Dunn-Sidak procedure (32) for testing a priori hypotheses, and Winer's (51) work dealing with reducing a test of equality of three means to a test of two orthogonal comparisons. A significance level of .05 was used to get a critical Dunn-Sidak t statistic of

2.427. The experimental t values of .365 and 1.096 for the two comparisons were less than 2.427. The Quiz class, Test class, and Control class were judged to be statistically equal relative to adjusted final examination performance in college algebra. This result was not expected by the researcher since Thorndike's distribution of practice theory (45, 46, 47) as related to frequency of testing was not supported. According to Thorndike, as well as other theoretical studies (5, 9, 30, 31, 37), repetition of a response (testing) with rest periods combined with feedback gives the learner a chance to correct errors and to profit from his experiences. Application of this theory means that frequent testing or required homework (Quiz class or Homework class) with their natural feedback for the student should lead to a significantly higher performance on a final examination in college algebra than either infrequent longer examinations (Test class) or no examinations (Control class).

Reactive inhibition as described by Hull (27) is the tendency to avoid repetition of a response once given. Combined with the distribution of practice theory, it seems that the quiz method of testing which involves smaller amounts of material with rest periods (several days between testing) would yield a significantly higher performance from a student than the test method or the Control class method. The latter testing procedures involve "massed

practice" and "no practice," respectively. The result obtained does not support this idea.

Most of the research done on frequent testing relative to its effect on performance in mathematics (and other disciplines) was not supported by the results presented by hypothesis 4(a). Harold E. Jones (28), the 1923 pioneer into frequency of testing research, found that classes tested "immediately" after each lecture profited enough so that twice as much content was retained as content not similarly examined. A later study by Turney (49) on the effect of frequent, short, objective quizzes upon achievement of college students in educational psychology yielded significant results. His means were adjusted using the Miller Mental Ability Test, Form B scores as pretest variables. Keys (29) refuted Turney's study with research results which showed that a group tested frequently in brief weekly installments did not differ significantly in retention of content from a group taking longer mid-term examinations. Keys' groups took tests identical in content and total amount and had two to ten times the number of subjects as in the Turney experiment. Keys also argued that Turney's groups differed widely in initial knowledge of the subject tested. The present research supports Keys work.

Dustin (20), Williams and Lawrence (50), Gaynor and Millham (23), and Semb (41) all did research leading to the conclusion that frequent quizzes over small units of

material aid students in performing better on later major examinations than students who are tested less frequently over larger units. These studies are consistent with the beliefs of the researcher, but were not supported by the current research. A major study done by Townsend and Wheatley (48) involved 442 beginning calculus students in 16 classes ranging in size from 11 to 35 students. A two-by-four-by-three factorial design was used with a two-way ANOVA to analyze the data. Townsend and Wheatley found that classes to which short daily quizzes were assigned had significantly higher achievement in performance than classes given only a midterm examination. This opposes the current findings. They also found from interaction effects that students' aptitudes do not need to be of prime consideration in deciding upon a testing strategy. This refutes the covariate effects discovered in the present study, i.e., pretest achievement in algebra (together with pretest attitude towards mathematics) has more effect on performance in college algebra than the type of testing strategy used.

Hypothesis 4(b).--There was a significant difference in adjusted mean attitude towards mathematics among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class. This result was obtained by using the Dunn-Sidak procedure (32) for testing a priori hypotheses, and Winer's (51) work dealing with

reducing a test of equality of three means to a test of two orthogonal comparisons. The Dunn-Sidak experimental t value was less than the critical t of 2.427 in one case ($t = 1.718$) but greater than the critical t in the other case ($t = 2.850$). The significant probability associated with the latter case was .02. This result meant that the Quiz class, Test class, and Control class differed significantly relative to adjusted posttest attitude towards mathematics.

This result was not expected by the researcher who agreed with the comprehensive study by Townsend and Wheatley (48) which was referenced earlier. In that study various levels of testing frequency and feedback were compared relative to posttest attitude towards mathematics with no significant differences reported. This was the only study found in the available literature which refuted the present findings. Aiken's research (1, 2, 3, 4) referenced in the previous hypotheses was supported by this study. Dustin (20) did a partial replication of Keys 1934 experiment which supported Aiken's results: frequent testing among groups gave a significant difference in test anxiety.

Hypothesis 4(c).--There was no significant difference in attrition rate among the groups which were tested in-class with different frequencies: Quiz class, Test class, and Control class. The overall Chi-square test for differences among the four testing strategy groups was

significant at the .05 level, but this a priori hypothesis was rejected. Each of the pairwise comparisons of means from the three classes of hypothesis 4(c) was accepted at the .05 significance level. Townsend and Wheatley's (48) extensive experiment referenced earlier was supported by the present result. They found no significant differences in proportion of students who withdrew from classes upon comparing various levels of feedback and testing frequency among groups.

The largest difference in attrition rate was 21.3 percent and occurred between the Quiz class and the Test class where the rates were 25.0 and 46.3 percent, respectively. It was expected that the Quiz class would have a significantly higher attrition rate than the other two classes. This was not true, but the attrition rates did differ enough to make it practical to use the information presented. It was found that the Test class had a high of 46.3 percent dropout rate with the control class second at 33.3 percent. The Homework class had the lowest attrition rate at 15.9 percent with the Quiz class just above with a 25.0 percent rate. Apparently, the Test class produced enough anxiety in a student to contribute to the possibility of him dropping out.

Demographics

The questionnaire administered at the onset of the study revealed the following: There were 78 females and 90 males who took part in the study. The relatively even split in gender was expected, but the average of 42 students per class was higher than usual. Normally there would be an average of 35 students per class. Consideration of the demographics and mathematical preparation of the students in the sample led to the following student research profile: the "typical" student in the study was a business major, seventeen to eighteen years of age, with an ACT score of between 19 and 24 who had two years of high school algebra preparation.

Opinion of the Subjects

An opinionnaire administered at the conclusion of the study asked two questions relative to the preference of the students for a testing strategy. The homework method for testing was chosen by 42.4 percent of the 118 students when given a choice among the four testing strategies as defined in this study. The traditional testing method, regular major examinations, was chosen by 33.9 percent. This outcome supports Taylor's study (44) where it was found from a questionnaire that compulsory homework was vigorously supported by both students and parents.

The second question on the opinionnaire involved the selection of a preferred testing strategy from the four in the study, or a combination of those strategies. Homework combined with regular testing was selected by 41.5 percent of the 118 subjects. This combination was chosen by a margin of three to one over the next choice; homework combined with weekly quizzes at 14.4 percent. This finding supports the study by Taylor (44) as well as Keys (28). Keys found from a questionnaire that students prefer "more frequent examination."

Conclusions and Implications

Based on the findings of the present study, the following conclusions and implications were derived:

1. The main purpose of this study was to compare the performance in college algebra of four testing strategy classes: Homework class, Quiz class, Test class, and the Control class. The findings from the sample of 118 students indicated that the adjusted mean scores in performance were not significantly different. In addition, it was found that there was no significant difference among the four testing strategy groups relative to final attitude towards mathematics. But the classes considered with their 168 original students did differ significantly at the .05 level relative to the criterion variable of class attrition rate.

There is a need for a testing strategy in college algebra classes, but apparently it makes no difference relative to performance on a final examination what type of strategy is used. Giving required homework, several short weekly quizzes, regular chapter tests, or just a midsemester and final examination are equally effective. This implies that the teacher should decide what method to use in each particular class to be most effective. Because there was no significant difference in the four testing strategies relative to attitude towards mathematics, it can be concluded that the teacher does not need to be concerned that the testing strategy employed will affect how a student feels about mathematics. However, the choice of testing strategy in a college algebra class does influence whether a student will eventually drop the class. In particular, using required homework serves to keep students in the class while the pressure of major examinations tends to cause dropouts. It was found that only the Homework class and the Test class differed significantly with respect to attrition rate. No other pairwise comparisons among the four testing strategy classes were significantly different at the .05 level. An implication here is that college algebra students should be given homework to be graded and returned by the teacher as a motivation for them to finish the course.

2. It appears that a portion of Kurt Lewin's field theory (tension in an educational environment enhances learning) was not supported by this study. The researcher perceived the Homework class as the "norm" relative to classroom tension. This class had little or no tension inspired by the frequent testing strategy employed: two weekly required homework assignments. The Quiz class was perceived as having a "large" amount of tension brought on by the requirement of taking two in-class quizzes (short tests) per week. When only comparing the Homework class and the Quiz class, no significant difference was found relative to performance on the final examination in college algebra. An implication here is that a student does not have to be under "extra" tension to perform well on a final examination in college algebra.

Extensive research done by Thorndike (45, 46, 47) and Hull (27) in distribution of practice and reactive inhibition, respectively, was not supported by the present study. According to their theories, frequent testing with reasonable rest periods between testings should enhance later performance by a learner. The researcher perceived the Quiz class, Test class, and Control class as three strategies involving distinctly different frequencies of testing. They ranged from twice weekly quizzes to monthly class-period examinations to midsemester and final examination only. In this context, the Quiz class should

have had a higher adjusted mean performance on the final examination in college algebra. This was not the case. When considering only these three classes, there was no significant difference at the .05 probability level. Again, the implication is that the teacher should choose a testing strategy which makes the classroom environment comfortable for both teacher and student.

3. When comparing all four testing strategies relative to final attitude towards mathematics, there was no significant difference caused by these strategies. Likewise, comparing just the Homework class with the Quiz class produced no significant difference. But upon comparing only the three classes: Quiz class, Test class, and Control class, there was a significant difference in final attitude with the adjusted mean largest for the Quiz class. The Quiz class developed a more positive attitude towards mathematics than either the Test class or the Control class, apparently due to the type of testing strategy they used. This result implies that if just in-class testing is being considered as the testing strategy, more frequent testing will improve the attitude of a student towards mathematics.

4. The instrument used to measure pretest and posttest attitude towards mathematics, the Aiken-Dreger Revised Mathematics Attitude Scale (RMAS) seemed to be adequate. The subjects had no difficulty interpreting the

questions and they seemed enthusiastic about responding. The test results were judged by the researcher to be an honest and accurate measure of the attitudes of the students towards mathematics.

The Cooperative Mathematics Test, Algebra II (CMTII), the Cooperative Mathematics Test, Arithmetic (CMTA), and the Cooperative Mathematics Test, Algebra III (CMTIII) used to measure pretest achievement in algebra, achievement in arithmetic, and posttest performance in college algebra, respectively, were also judged to be accurate measurements of the indicated variables. In particular, the CMTIII was a good, comprehensive final examination for a college algebra class in the researcher's opinion. Judging from grading the examinations and receiving student comments, it is believed that the results were fair and accurate. An important consequence is that the CMTIII is recommended for final testing in college algebra classes. It could also be used as a proficiency examination for freshmen or sophomores in colleges and universities where "mass" examinations are required.

5. The limitations of this study were not judged to be important factors in the results obtained. The students in the intact classes were similar in gender, age, and mathematical preparation, and the use of ANCOVA enabled the researcher to equate the classes in algebra and arithmetic achievement as well as in pretest attitude towards

mathematics. The Nonequivalent Control Group Design (5) was used in place of randomization; an exception was that the four experimental classes were randomly assigned to the four testing strategy treatments. The results of the study appear to be generalizable to other areas of freshman mathematics classes as well as to colleges and universities similar to Louisiana State University in Shreveport.

6. Regarding the basic assumptions of the study, the researcher believes that the test strategies used in the Homework class and Quiz class did create different degrees of tension in their respective classes as suggested by Lewinian field theory. It is believed that the in-class testing strategies utilizing different frequencies of testing were applications of the theoretical constructs of distribution of practice and reactive inhibition as conceived by Thorndike and Hull, respectively. More feedback was observed in the Homework and Quiz classes than in the Test and Control classes. The subjects in the four classes seemed to become aware that the researcher was testing the classes differently, but no obvious problems were observed relative to Hawthorne or John Henry effects.

Recommendations

Based on the conclusions and implications of this study, the following recommendations are made.

1. Similar studies should be done in other subjects within mathematics as well as in other disciplines to determine if similar results can be obtained.
2. Replication of the present study should be done by other teachers at other colleges and universities to determine if the teacher or the school have any effect on the results.
3. A study needs to be done involving comparisons of combinations of testing strategies using the same teacher and various dependent variables.
4. The pretest variables of achievement in algebra and achievement in arithmetic should not both be used in future studies due to their strong relationship.
5. A similar study should be done with just three groups of college algebra students: Quiz class, Test class, and Control class, to determine if these classes differ relative to attitude towards mathematics. The significant difference obtained in the present study relative to attitude towards mathematics was borderline.
6. Stronger and more refined studies need to be done to find other causes of higher attrition rate in college algebra classes as well as classes in other disciplines.
7. The use of required homework is recommended by this researcher as a principal testing strategy especially as a means by which retention can be improved in the college algebra classroom.

CHAPTER BIBLIOGRAPHY

1. Aiken, Lewis R., and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52, No. 1 (February, 1961), 19-24.
2. Aiken, Lewis R., "Personality Correlates of Attitude Toward Mathematics," The Journal of Educational Research, 56, No. 9 (May-June, 1963), 476-480.
3. _____, "Research on Attitudes Toward Mathematics," The Arithmetic Teacher, 19, No. 3 (March, 1972), 229-234.
4. _____, "Two Scales of Attitude Toward Mathematics," Journal for Research in Mathematics Education, 5, No. 2 (March, 1974), 67-71.
5. Ammons, R. B., "Rotary Pursuit Performance with Continuous Practice before and after a Single Rest," Journal of Experimental Psychology, 37 (October, 1947), 393-411.
6. Anderson, William E., "An Attempt Through the Use of Experimental Techniques to Determine the Effect of Home Assignments Upon Scholastic Success," Journal of Educational Research, 40, No. 2 (October, 1946), 141-143.
7. Anttonen, Ralph G., "A Longitudinal Study in Mathematics Attitude," The Journal of Educational Research, 62, No. 10 (July-August, 1969), 467-471.
8. Astin, Alexander W., Preventing Students from Dropping Out, San Francisco, Jossey-Bass, 1975.
9. Behrman, J. A., Veronica J. Dark, and Stephen C. Paul, "The Effects of a Structured Learning-Skills Intervention on Long-Term Academic Performance," Journal of College Student Personnel, 25, (July, 1984), 326-331.
10. Black, Ken and William K. Brookshire, "Hypothesis Testing: Proportions," unpublished paper presented to Dr. Curry, EDER 625, North Texas State University, Denton, Texas, (January, 1979), 10-16.

11. Borg, Walter R. and Meredith D. Gall, Educational Research, 4th ed., New York, Longman, 1983.
Springfield, Ill., Charles Thomas, 1975.
12. Campbell, Donald T. and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally College Publishing Company, 1963.
13. Cartledge, Carolyn M. and John E. Sasser, The Effect of Homework Assignments on the Mathematics Achievement of College Students in Freshman Algebra, (Report No. SE035577), Georgia, (ERIC Document Reproduction No. ED 206 495), 1982.
14. Cope, Robert G. and Raymond William Hewitt, Revolving College Doors: The Causes and Consequences of Dropping Out, Stopping Out, and Transferring, New York, John Wiley and Sons, 1975.
15. _____, "Types of College Dropouts: An Environmental Press Approach," College Student Journal, 5 (September, 1971), 46-51.
16. Davis, James R., Teaching Strategies for the College Classroom, Boulder, Colorado, Westview Press, Inc., 1976.
17. DeVechio, Richard C., "Characteristics of Nonreturning Community College Freshmen," The Journal of College Student Personnel, 13 (September, 1972), 429-432.
18. Deutsch, M. and Krauss, R. M., Theories in Social Psychology, New York, Basic Books, 1965.
19. Douthitt, Cameron E., The Effect of Written Examinations on Attitude and Achievement in College Freshman Mathematics at Alvin Community College, (Report No. SE024330), Alvin Community Coll., Texas, (ERIC Document Reproduction No. ED 156 440), 1978.
20. Dustin, D. S., "Some Effects of Exam Frequency," The Psychological Record, 21, No. 3 (Summer, 1971), 409-414.
21. Ferguson, George A., Statistical Analysis in Psychology and Education, 5th ed., New York, McGraw-Hill Book Company, 1981.

22. Friesen, C., The Results of Homework Versus No-Homework Research Studies, paper presented to the University of Iowa, (ERIC Document Reproduction No. ED 167 508), 1979.
23. Gaynor, J., and J. Millham, "Student Performance and Evaluation Under Variant Teaching and Testing Methods in a Large College Course," Journal of Educational Psychology, 68, No. 3 (June, 1976), 312-317.
24. Goldstein, Avram, "Does Homework Help? A Review of Research," The Elementary School Journal, 60 (January, 1960), 212-224.
25. Handbook Cooperative Mathematics Tests, Monterey, California, CTB/McGraw-Hill, 1964.
26. Hansen, David W., "An Investigation of the Effects of Required Homework on Achievement in Mathematics," Dissertation Abstracts International, 33 (December, 1972), 2814A-2815A.
27. Hull, C. L., Principles of Behavior, New York, Appleton-Century-Crofts, 1943, pp. 35-49.
28. Jones, Harold E., "Experimental Studies of College Teaching," Archives of Psychology, No. 68, 1923, pp. 1-62.
29. Keys, Noel, "The Influence of Learning and Retention of Weekly as Opposed to Monthly Tests," The Journal of Educational Psychology, 25 (September, 1934), 427-436.
30. Kimble, G. A., "An Experimental Test of a Two-Factor Theory of Inhibition," Journal of Experimental Psychology, 39 (February, 1949), 15-23.
31. Kingsley, H. L. and Ralph Garry, The Nature and Conditions of Learning, 2nd ed., Englewood Cliffs, N. J., Prentice-Hall, Inc., 1957.
32. Kirk, Roger E., Experimental Design: Procedures for the Behavioral Sciences, 2nd ed., Belmont, California, Brooks/Cole Publishing Company, 1982.
33. Lewin, Kurt, Field Theory in Social Science. New York, Harper & Brothers, 1951.

34. Maertens, N. and J. Johnston, "Effects of Arithmetic Homework Upon the Attitudes and Achievement of Fourth, Fifth, and Sixth Grade Pupils," School Science and Mathematics, 72, No. 2 (February, 1972), 117-126.
35. Mason, Lysle C., "A Study of the Influence of Compulsory Homework on the Achievement of College Students in College Algebra," Dissertation Abstracts International, 28 (July, 1967), 56A.
36. Matthes, L. J., "A Comparative Study of the Effects of Required Homework or Quizzes on Achievement in an Undergraduate Mathematics Service Course," unpublished doctoral dissertation, The University of Tennessee, Lynchburg, Tennessee, 1978.
37. McGeoch, J. A., "The Influence of Degree of Interpolated Learning upon Retroactive Inhibition," American Journal of Psychology, 44 (October, 1932), 695-708.
38. Neale, Daniel C., "The Role of Attitudes in Learning Mathematics," Arithmetic Teacher, 16 (December, 1969), 631-640.
39. Parrish, D. C. "An Investigation of the Effects of Required Drill Homework Versus No Homework on Attitudes Toward and Achievement in Mathematics," unpublished doctoral dissertation, University of Houston, Houston, Texas, 1976.
40. Schmidt, Gary E., "The Effectiveness of Large Lecture Recitation Sections Versus Small Group Classes and the Influence of Compulsory-Homework-and-Quizzes on the Achievement and Attitudes of Calculus II Students," unpublished doctoral dissertation, Department of Education, Kansas State University, (Manhattan, Kansas), 1973.
41. Semb, G., "The Effects of Mastery Criteria and Assignment Length on College Student Test Performance," Journal of Applied Behavior Analysis, 7 (Spring, 1974), 60-69.
42. SPSS^X User's Guide, 2nd ed., New York, McGraw-Hill Book Company, 1986.

43. Swensen, Ester J., James C. Cost, and Greene Y. Taylor, "Research on Homework," Journal of Education, 137 (March, 1955), 20-22.
44. Taylor, Harold D., "A Comparative Study of Compulsory Homework Versus Non-Compulsory Homework in Algebra I and Geometry I at Hillsdale High School," Dissertation Abstracts International, 32 (January, 1972), 3876A.
45. Thorndike, E. L., Human Learning, New York, Appleton, 1931.
46. _____, The Fundamentals of Learning, New York, Teachers College, Columbia Univ., 1932.
47. _____, Human Nature and the Social Order, New York, Macmillan, 1940.
48. Townsend, Neal R. and Grayson H. Wheatley, "Analysis of Frequency of Tests and Varying Feedback Delays in College Mathematics Achievement," College Student Journal, 9, No. 1 (February-March, 1975), 32-36.
49. Turney, Austin H., "The Effect of Frequent Short Objective Tests Upon the Achievement of College Students in Educational Psychology," School and Society, 33, No. 858 (June 6, 1931), 760-762.
50. Williams, R. L. and J. Lawrence, "The Effects of Frequency of Quizzing in a Lecture Course," Research and Technology in College and University Teaching, edited by G. W. O'Neill, Georgia State University, Urban Life Center, 1974, pp. 75-82.
51. Winer, B. J., Statistical Principles in Experimental Design, New York, McGraw-Hill Book Company, 1971.
52. Zorn, P., "Calculus Redux," Focus, 6, No. 2 (March-April, 1986), 1-2, 5.

APPENDICES

APPENDIX A
Math 121 Syllabus

SYLLABUS

MATHEMATICS 121
College Algebra
3 credits

AUGUST, 1986

DESCRIPTION: Prerequisite is two years of high school algebra or Mathematics 111 or consent of department. Non linear relations and functions; exponential and logarithmic functions; systems of equations and inequalities; matrices and determinants; sequences and series; binomial theorem.

TEXT: The Sixth Edition of College Algebra by Beckenbach, Drooyan, and Grady.

TEACHING METHOD: Lecture-problem-solving procedure with 3 hours of lecture per week.

COURSE OBJECTIVES: To present college algebra topics with sufficient rigor so a student will be prepared for any discipline requiring algebra.

COURSE OUTLINE:

1. REVIEW SECTIONS: 1.6, 1.7, 2.2 - 2.5, 3.1, 3.3, 3.4, 3.6, 3.8, and 3.9
2. REGULAR MATERIAL: Chapters 4 - 9 (except sections 7.6 and 7.7)
3. OPTIONAL MATERIAL: Chapters 10 and 11

APPENDIX B

Math 121 Information Sheet - Quiz Class

INFORMATION SHEET

MATHEMATICS 121
10 - 10:50 MWF

Course Instructor: Charlie Johnson Office: BH 416

Office hours: MWF 8-9, 11-12:30 Phone: 797-5301
TTh 8-9:30, 12:15-12:30
or by appointment

Course organization:

There will be 42 MWF class meetings with the last class occurring on Friday, December 5. We will use three classes for introductory material, five classes for review material, and one class for a mid-semester examination. The remaining 33 classes will be used to cover the regular material of Math 121, i.e., chapters 4 through 9.

Attendance:

You should attend every class. If you know in advance that you must be absent, please let me know when and why you must miss. All quizzes and tests which are missed must be made up. Please contact me to schedule makeups!!

Testing:

There will be a 10 to 15 minute quiz given on Wednesday and Friday of each week consisting of a few problems from the previous class meeting's homework assignment. There will be approximately 24 of these quizzes. There will be a 50-minute mid-semester examination and a cumulative final examination.

Grading:

The mid-semester examination will count 25 percent of the final course grade and the final examination will count 25 percent. The overall grade on the quizzes will count 50 percent of the final grade.

The grading structure will basically be:

- 90 - 100 percent for an A
- 80 - 89 percent for a B
- 70 - 79 percent for a C
- 60 - 69 percent for a D
- 59 and below for an F

It should be noted that the final grade will be given on the basis of overall evaluation and may not follow the above scale exactly!

Homework:

All homework should be completed on time so you can ask questions in class before the quiz is given. The homework will not be taken up and graded!

APPENDIX C

Math 121 Information Sheet - Homework Class

INFORMATION SHEET

MATHEMATICS 121
9 - 9:50 MWF

Course Instructor: Charlie Johnson Office: BH 416

Office hours: MWF 8-9, 10-11, 12-12:30 Phone: 797-5301
TTh 8-9:30, 12:15-12:30
or by appointment

Course organization:

There will be 42 MWF class meetings with the last class occurring on Friday, December 5. We will use three classes for introductory material, five classes for review material, and one class for a mid-semester examination. The remaining 33 classes will be used to cover the regular material of Math 121, i.e., chapters 4 through 9.

Attendance:

You should attend every class. If you know in advance that you must be absent, please let me know when and why you must miss. All homework and tests which are missed must be made up. Please contact me to schedule makeups!!

Testing:

Homework will be assigned each class period. The assignments given on Monday and Wednesday will be taken up on Wednesday and Friday, respectively, graded and returned to you. No homework assignment will be given on Friday. There will be approximately 24 homework assignments. There will be a 50-minute mid-semester examination and a cumulative final examination.

Grading:

The mid-semester examination will count 25 percent of the final course grade and the final examination will count 25 percent. The overall grade on the homework will count 50 percent of the final grade.

The grading structure will basically be:

- 90 - 100 percent for an A
- 80 - 89 percent for a B
- 70 - 79 percent for a C
- 60 - 69 percent for a D
- 59 and below for an F

It should be noted that the final grade will be given on the basis of overall evaluation and may not follow the above scale exactly!

APPENDIX D

Math 121 Information Sheet - Test Class

INFORMATION SHEET

MATHEMATICS 121
11 - 12:15 TTh

Course Instructor: Charlie Johnson Office: BH 416

Office hours: MWF 8-9, 11-12:30 Phone: 797-5301
 TTh 8-9:30, 12:15-12:30
 or by appointment

Course organization:

There will be 29 TTh class meetings with the last class occurring on Thursday, December 4. We will use two classes for introductory material, three classes for review material, and one class for a mid-semester examination. The remaining 23 classes will be used to cover the regular material of Math 121, i.e., chapters 4 through 9.

Attendance:

You should attend every class. If you know in advance that you must be absent, please let me know when and why you must miss. All tests which are missed must be made up. Please contact me to schedule makeups!!

Testing:

There will be four 75-minute tests given during the semester. Each test will cover the material covered since the last test. A 75-minute mid-semester examination and a final examination (both cumulative) will also be given.

Grading:

The mid-semester examination will count 25 percent of the final course grade and the final examination will count 25 percent. The overall grade on the four tests will count 50 percent of the final grade.

The grading structure will basically be:

- 90 - 100 percent for an A
- 80 - 89 percent for a B
- 70 - 79 percent for a C
- 60 - 69 percent for a D
- 59 and below for an F

It should be noted that the final grade will be given on the basis of overall evaluation and may not follow the above scale exactly!

Homework:

All homework should be completed on time so you can ask questions in class and thereby have correct solutions to the problems. The homework will not be taken up and graded!

APPENDIX E

Math 121 Information Sheet - Control Class

INFORMATION SHEET

MATHEMATICS 121
9:30 - 10:45 TTh

Course Instructor: Charlie Johnson Office: BH 416

Office hours: MWF 8-9, 11-12:30 Phone: 797-5301
 TTh 8-9:30, 12:15-12:30
 or by appointment

Course organization:

There will be 29 TTh class meetings with the last class occurring on Thursday, December 4. We will use two classes for introductory material, three classes for review material, and one class for a mid-semester examination. The remaining 23 classes will be used to cover the regular material of Math 121, i.e., chapters 4 through 9.

Attendance:

You should attend every class. If you know in advance that you must be absent, please let me know when and why you must miss.

Testing:

There will be a 75-minute mid-semester examination and a cumulative final examination.

Grading:

The mid-semester examination will count 50 percent of the final course grade and the final examination will count 50 percent.

The grading structure will basically be:

- 90 - 100 percent for an A
- 80 - 89 percent for a B
- 70 - 79 percent for a C
- 60 - 69 percent for a D
- 59 and below for an F

It should be noted that the final grade will be given on the basis of overall evaluation and may not follow the above scale exactly!

Homework:

All homework should be completed on time so you can ask questions in class and thereby have correct solutions to the problems. The homework will not be taken up and graded!

APPENDIX F
Mathematics Attitude Scale

MATHEMATICS ATTITUDE SCALE

Directions: Please write your name in the upper right hand corner. Each of the statements on this opinionnaire expresses a feeling which a particular person has toward mathematics. You are to express, on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five points are: Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). You are to encircle the letter(s) which best indicates how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

1. I am always under a terrible strain in a math class.
SD D U A SA
2. I do not like mathematics, and it scares me to have to take it.
SD D U A SA
3. Mathematics is very interesting to me, and I enjoy math courses.
SD D U A SA
4. Mathematics is fascinating and fun.
SD D U A SA
5. Mathematics makes me feel secure, and at the same time it is stimulating.
SD D U A SA
6. My mind goes blank, and I am unable to think clearly when working math.
SD D U A SA
7. I feel a sense of insecurity when attempting mathematics.
SD D U A SA
8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
SD D U A SA
9. The feeling that I have toward mathematics is a good feeling.
SD D U A SA
10. Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.
SD D U A SA

11. Mathematics is something which I enjoy a great deal.
SD D U A SA
12. When I hear the word math, I have a feeling of dislike.
SD D U A SA
13. I approach math with a feeling of hesitation, resulting from a fear of not being able to do math.
SD D U A SA
14. I really like mathematics.
SD D U A SA
15. Mathematics is a course in school which I have always enjoyed studying.
SD D U A SA
16. It makes me nervous to even think about having to do a math problem.
SD D U A SA
17. I have never liked math, and it is my most dreaded subject.
SD D U A SA
18. I am happier in a math class than in any other class.
SD D U A SA
19. I feel at ease in mathematics, and I like it very much.
SD D U A SA
20. I feel a definite positive reaction to mathematics; it's enjoyable.
SD D U A SA

APPENDIX G
Demographic Data Sheet

APPENDIX H
Opinionnaire

OPINIONNAIRE

Please answer the following:

1. You are now completing Math 121. You have had a midsemester examination and are about to have a final examination. If you could count only one other testing procedure as 50 percent of your final course grade, would you prefer: (circle only one choice please!)

- (a) to take two in-class quizzes each week,
- (b) to hand in two homework assignments each week,
- (c) to take four class-period examinations spread evenly over the semester, or
- (d) to not use any testing procedure except the midsemester and final examinations.

2. If you had a choice about how you would be tested in Math 121 and you could choose one or combine several testing procedures, would you prefer: (circle only one choice please!)

- (a) to take two in-class quizzes each week,
- (b) to hand in two homework assignments each week,
- (c) to take four class-period examinations spread evenly over the semester,
- (d) to not use any testing procedure except the midsemester and final examinations,
- (e) to combine (a) and (b), i.e., to take quizzes and hand in homework,
- (f) to combine (a) and (c), i.e., to take quizzes and tests,
- (g) to combine (b) and (c), i.e., to take homework and tests, or
- (h) to combine (a) and (b) and (c), i.e., to take quizzes, hand in homework, and take tests.

APPENDIX I

Letter to Dr. Lewis R. Aiken

Charles W. Johnson
558 E. Windsor
Denton, TX 76201

April 5, 1986

Dr. Lewis R. Aiken
Department of Psychology
Pepperdine University
Malibu, CA 90265

Dear Dr. Aiken:

I am a doctoral student in College Teaching/Mathematics at North Texas State University in Denton, Texas. My dissertation research is related to performance in and attitude toward mathematics. I am interested in the Revised Math Attitude Scale from your 1963 paper "Personality Correlates of Attitude Toward Mathematics." I am also interested in the update you published in the March, 1974 issue of Journal for Research in Mathematics Education entitled "Two scales of Attitude Toward Mathematics."

Data will be collected in the fall of 1986 from four algebra classes in a Louisiana university. Three treatments will be used involving frequency of quizzing and homework. I would like to measure attitude toward mathematics as a pretest covariate. It will also be used as a posttest dependent variable.

I am writing to ask permission to use the two tests referenced above. If you cannot grant permission please inform me how I can obtain the use of these tests. Information on scoring, reliability, and validity would also be appreciated.

Thank you for your time.

Sincerely,

Charles W. Johnson

Charles W. Johnson
Assistant Professor of Mathematics
Louisiana State University
in Shreveport

Permission Granted
OK.
LR Aiken

APPENDIX J

Letter to Publishers Test Service

Charles W. Johnson
558 E. Windsor
Denton, TX 76201

June 23, 1986

Publishers Test Service
CTB/McGraw-Hill
2500 Garden Road
Monterey, California 93940-5380

Dear Representative:

I would like to order the CMT tests indicated on the enclosed order form. Enclosed you will find my check for \$158.31 to cover the \$135.30 materials cost, \$16.24 UPS surface charges, and 5% tax of \$6.77.

You will also find Dr. Howard W. Smith's signature endorsing my order of these test materials. Dr. Smith is my major professor and the one who is directing the research for which these tests will be used. Thank you for your attention in this order.

Sincerely,

Charles W. Johnson
Assistant Professor of Mathematics
Louisiana State University
in Shreveport

NOTE: Charles W. Johnson has my approval to order and use the CTM test materials indicated on the enclosed order form.

Howard W. Smith 6/23/86
Major Professor Date
Professor of Education
North Texas State University

BIBLIOGRAPHY

Books

- Astin, Alexander W., Preventing Students from Dropping Out, San Francisco, Jossey-Bass, 1975.
- Borg, Walter R. and Meredith D. Gall, Educational Research, 4th ed., New York, Longman, 1983.
- Born, D. G., "Exam Performance and Study Behavior as a Function of Study Unit Size in a PSI Course," Behavior Research and Technology in Higher Education, edited by James M. Johnston, Springfield, IL., Charles Thomas, 1975, pp. 269-282.
- Brookshire, William K., SPSS: Printouts of Illustrative Examples and Exercises from Ferguson's 5th Edition, Denton, Texas, North Texas State University, 1984.
- Buros, Oscar K., editor, The Seventh Mental Measurements Yearbook, 2, Highland Park, N. J., The Gryphon Press, 1972.
- Caldwell, James R., "Cooperative Mathematics Test, Algebra III," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 896-897.
- Campbell, Donald T. and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, Chicago, Rand McNally College Publishing Company, 1963.
- Cohen, Arthur M., Dateline '79: Historical Concepts for the Community Colleges, Beverly Hills, Glencoe Press, 1969.
- Cook, Thomas D. and Donald T. Campbell, Quasi-Experimentation Design & Analysis Issues for Field Settings, Boston, Houghton Mifflin Company, 1979.
- Cope, Robert G. and Raymond William Hewitt, Revolving College Doors: The Causes and Consequences of Dropping Out, Stopping Out, and Transferring, New York, John Wiley and Sons, 1975.

- Davis, James R., Teaching Strategies for the College Classroom, Boulder, Colorado, Westview Press, Inc., 1976.
- Deutsch, M. and Krauss, R. M., Theories in Social Psychology, New York, Basic Books, 1965.
- Ferguson, George A., Statistical Analysis in Psychology and Education, 5th ed., New York, McGraw-Hill Book Company, 1981.
- Hoyt, Donald P., "A Retrospective and Prospective Examination of Retention-Attrition Research," In Reducing the Dropout Rate, edited by Lee Noel, San Francisco, Jossey-Bass, 1978, pp. 77-85.
- Huck, Schuyler W., William H. Cormier, and William G. Bounds, Jr., Reading Statistics and Research, New York, Harper & Row, 1974.
- Kerlinger, Fred N. and Elazar J. Pedhazur, Multiple Regression in Behavioral Research, New York, Holt Rinehart and Winston, Inc., 1973.
- Kleinbaum, David G. and Lawrence L. Kupper, Applied Regression Analysis and Other Multivariable Methods, North Scituate, Massachusetts, Duxbury Press, 1978.
- Kingsley, H. L. and Ralph Garry, The Nature and Conditions of Learning, 2nd ed., Englewood Cliffs, N. J., Prentice-Hall, Inc., 1957.
- Kirk, Roger E., Experimental Design: Procedures for the Behavioral Sciences, 2nd ed., Belmont, California, Brooks/Cole Publishing Company, 1982.
- Lewin, Kurt, Field Theory in Social Science. New York, Harper & Brothers, 1951.
- Norsusis, Marija J., SPSS^x Introductory Statistics Guide, New York, McGraw-Hill Book Company, 1983.
- _____, SPSS^x Advanced Statistics Guide, New York, McGraw-Hill Book Company, 1985.
- Osborne, Alan R., "Cooperative Mathematics Test, Arithmetic," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 914-915.

- Romberg, Thomas A., and Thomas P. Carpenter, "Research on Teaching and Learning Mathematics: Two Disciplines of Scientific Inquiry," Handbook of Research on Teaching, 3rd ed., edited by Merlin C. Wittrock, New York, Macmillan Pub. Co., 1986, pp. 850-873.
- Roueche, John E., George A. Baker III, and Richard L. Brownell, Accountability and the Community College, Washington, American Association of Junior Colleges, 1971.
- Shaw, Marvin E. and Jack M. Wright, Scales for the Measurement of Attitudes, New York, McGraw-Hill Publishing Company, 1967.
- SPSS^x User's Guide, 2nd ed., New York, McGraw-Hill Book Company, 1986.
- Thorndike, E. L., The Psychology of Learning, Vol. 2 of Educational Psychology, New York, Teachers College, Columbia, Univ., 1913.
- _____, Human Learning, New York, Appleton, 1931.
- _____, The Fundamentals of Learning, New York, Teachers College, Columbia Univ., 1932.
- _____, Human Nature and the Social Order, New York, Macmillan, 1940.
- Travers, Kenneth J., "Cooperative Mathematics Test, Algebra II," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 894-896.
- Warrington, Willard G., "Cooperative Mathematics Test, Algebra III," The Seventh Mental Measurements Yearbook, edited by Oscar K. Buros (2 volumes), Highland Park, N. J., The Gryphon Press, 1972, pp. 897-899.
- Winer, B. J., Statistical Principles in Experimental Design, New York, McGraw-Hill Book Company, 1971.

Articles

- Aiken, Lewis R., and Ralph M. Dreger, "The Effect of Attitudes on Performance in Mathematics," Journal of Educational Psychology, 52, No. 1 (February, 1961), 19-24.

- Aiken, Lewis R., "Personality Correlates of Attitude Toward Mathematics," The Journal of Educational Research, 56, No. 9 (May-June, 1963), 476-480.
- _____, "Research on Attitudes Toward Mathematics," The Arithmetic Teacher, 19, No. 3 (March, 1972), 229-234.
- _____, "Two Scales of Attitude Toward Mathematics," Journal for Research in Mathematics Education, 5, No. 2 (March, 1974), 67-71.
- Ammons, R. B., "Rotary Pursuit Performance with Continuous Practice before and after a Single Rest," Journal of Experimental Psychology, 37 (October, 1947), 393-411.
- Anderson, William E., "An Attempt Through the Use of Experimental Techniques to Determine the Effect of Home Assignments Upon Scholastic Success," Journal of Educational Research, 40, No. 2 (October, 1946), 141-143.
- Anttonen, Ralph G., "A Longitudinal Study in Mathematics Attitude," The Journal of Educational Research, 62, No. 10 (July-August, 1969), 467-471.
- Behrman, J. A., Veronica J. Dark, and Stephen C. Paul, "The Effects of a Structured Learning-Skills Intervention on Long-Term Academic Performance," Journal of College Student Personnel, 25 (July, 1984), 326-331.
- Cope, Robert G. and Raymond William Hewitt, "Types of College Dropouts: An Environmental Press Approach," College Student Journal, 5 (September, 1971), 46-51.
- DeVechio, Richard C., "Characteristics of Nonreturning Community College Freshmen," The Journal of College Student Personnel, 13 (September, 1972), 429-432.
- Dustin, D. S., "Some Effects of Exam Frequency," The Psychological Record, 21, No. 3 (Summer, 1971), 409-414.
- Easley, H., "The Curve of Forgetting and the Distribution of Practice," Journal of Educational Psychology, 28 (September, 1937), 474-478.
- Fitch, Mildred L., A. J. Drucker, and J. A. Norton, Jr., "Frequent Testing As A Motivating Factor In Large Lecture Classes," The Journal of Educational Psychology, 42, No. 1 (January, 1951), 1-20.

- Gaynor, J., and J. Millham, "Student Performance and Evaluation Under Variant Teaching and Testing Methods in a Large College Course," Journal of Educational Psychology, 68, No. 3 (June, 1976), 312-317.
- Goldstein, Avram, "Does Homework Help? A Review of Research," The Elementary School Journal, 60 (January, 1960), 212-224.
- Gough, M. F., "Mathemaphobia: Causes and Treatments," Clearing House, 28, 1954, pp. 290-294.
- Hannah, William, "Personality Differences Between Lower Division Dropouts and Stay-Ins," The Journal of College Student Personnel, 12 (January, 1971), 12, 16-19.
- Hines, V. A., "Homework and Achievement in Plane Geometry," The Mathematics Teacher, 50 (January, 1957), 27-29.
- Hull, C. L., Principles of Behavior, New York, Appleton-Century-Crofts, 1943, pp. 35-49.
- Jones, Harold E., "Experimental Studies of College Teaching," Archives of Psychology, 68, (1923), 1-62.
- Keys, Noel, "The Influence of Learning and Retention of Weekly as Opposed to Monthly Tests," The Journal of Educational Psychology, 25 (September, 1934), 427-436.
- Kimble, G. A., "An Experimental Test of a Two-Factor Theory of Inhibition," Journal of Experimental Psychology, 39 (February, 1949), 15-23.
- Köhler, Emmett T., "The Relationship Between the Cooperative Mathematics Test, Algebra III, ACT Mathematics Usage Test, ACT Composite and Grade Point Average in College Algebra," Educational and Psychological Measurement, 31, No. 4 (Winter, 1973), 929-931.
- Maertens, N. and J. Johnston, "Effects of Arithmetic Homework Upon the Attitudes and Achievement of Fourth, Fifth, and Sixth Grade Pupils," School Science and Mathematics, 72, No. 2 (February, 1972), 117-126.
- Martin, R. R. and Kam Srikameswaran, "Correlation Between Frequent Testing and Student Performance," Journal of Chemical Education, 51, No. 7 (July, 1974), 485-486.

- McCallon, Earl L., and John D. Brown, "A Semantic Differential Instrument For Measuring Attitude Toward Mathematics," The Journal of Experimental Education, 39, No. 4, 1971, pp. 69-72.
- McGeoch, J. A., "The Influence of Degree of Interpolated Learning upon Retroactive Inhibition," American Journal of Psychology, 44 (October, 1932), 695-708.
- Mulry, J. G., "We Need Research on Homework," NEA Journal, 50, No. 4 (April, 1961), 49.
- Neale, Daniel C., "The Role of Attitudes in Learning Mathematics," Arithmetic Teacher, 16 (December, 1969), 631-640.
- Pedrini, D. T. and Bonnie C. Pedrini, "Reading Abilities and College Grades," College Student Journal, 9, No. 1 (February-March, 1975), 37-42.
- Poffenberger, T. N., and D. A. Norton, "Factors Determining Attitudes Toward Arithmetic and Mathematics," Arithmetic Teacher, 3, 1956, pp. 113-116.
- Semb, G., "The Effects of Mastery Criteria and Assignment Length on College Student Test Performance," Journal of Applied Behavior Analysis, 7 (Spring, 1974), 60-69.
- Swensen, Ester J., James C. Cost, and Greene Y. Taylor, "Research on Homework," Journal of Education, 137 (March, 1955), 20-22.
- Townsend, Neal R. and Grayson H. Wheatley, "Analysis of Frequency of Tests and Varying Feedback Delays in College Mathematics Achievement," College Student Journal, 9, No. 1 (February-March, 1975), 32-36.
- Tulock, M. K., "Emotional Blocks in Mathematics," Mathematics Teacher, 50, 1957, pp. 572-576.
- Turney, Austin H., "The Effect of Frequent Short Objective Tests Upon the Achievement of College Students in Educational Psychology," School and Society, 33, No. 858 (June 6, 1931), 760-762.
- Verner, Coolie and George S. Davis Jr., "Completions and Drop Outs: A Review of Research," Adult Education, 14 (Spring, 1964), 157-176.

Weaver, H. B., "The Mathematical Proficiency of Students of Psychology," Journal of Educational Research, 51, 1957, pp. 161-170.

Williams, R. L. and J. Lawrence, "The Effects of Frequency of Quizzing in a Lecture Course," Research and Technology in College and University Teaching, edited by G. W. O'Neill, Georgia State University, Urban Life Center, 1974, pp. 75-82.

Wilson, Russell C., "Personological Variables Related to GED Retention and Withdrawal," Adult Education, 30 (Spring, 1980), 173-185.

Zorn, P., "Calculus Redux," Focus, 6, No. 2 (March-April, 1986), 1-2, 5.

Report

National Institute of Education, Involvement in Learning: Realizing the Potential of American Higher Education, Final Report of the Study Group on the Conditions of Excellence in American Higher Education, Washington D.C., Department of Education, 1984.

Publication of Learned Organization

Handbook Cooperative Mathematics Tests, Monterey, California, CTB/McGraw-Hill, 1964.

Public Documents

Cartledge, Carolyn M. and John E. Sasser, The Effect of Homework Assignments on the Mathematics Achievement of College Students in Freshman Algebra, (Report No. SE035577), Georgia, (ERIC Document Reproduction No. ED 206 495), 1982.

Douthitt, Cameron E., The Effect of Written Examinations on Attitude and Achievement in College Freshman Mathematics at Alvin Community College, (Report No. SE024330), Alvin Community Coll., Texas, (ERIC Document Reproduction No. ED 156 440), 1978.

Friesen, C., The Results of Homework Versus No-Homework Research Studies, paper presented to the University of Iowa, (ERIC Document Reproduction No. ED 167 508), 1979.

Texas Education Agency, Course Withdrawal Data Summary--Fall 1976, Texas-SIS Follow Up, Postsecondary Student Follow-Up Management Information System, (Monograph 2), Austin, Texas, (Eric Document Reproduction No. ED 140 905), 1977.

Thompson, J. Robert, Why Students Drop Courses, McComb County Community College, (Eric Document Reproduction No. ED 026 994), 1969.

Dissertation Abstracts

Hansen, David W., "An Investigation of the Effects of Required Homework on Achievement in Mathematics," Dissertation Abstracts International, 33 (December, 1972), 2814A-2815A.

Mason, Lysle C., "A Study of the Influence of Compulsory Homework on the Achievement of College Students in College Algebra," Dissertation Abstracts International, 28 (July, 1967), 56A.

Taylor, Harold D., "A Comparative Study of Compulsory Homework Versus Non-Compulsory Homework in Algebra I and Geometry I at Hillsdale High School," Dissertation Abstracts International, 32 (January, 1972), 3876A.

Unpublished Material

Black, Ken and William K. Brookshire, "Hypothesis Testing: Proportions," unpublished paper presented to Dr. Curry, EDER 625, North Texas State University, Denton, Texas, (January, 1979), 10-16.

Matthes, L. J., "A Comparative Study of the Effects of Required Homework or Quizzes on Achievement in an Undergraduate Mathematics Service Course," unpublished doctoral dissertation, The University of Tennessee, Lynchburg, Tennessee, 1978.

Parrish, D. C. "An Investigation of the Effects of Required Drill Homework Versus No Homework on Attitudes Toward and Achievement in Mathematics," unpublished doctoral dissertation, University of Houston, Houston, Texas, 1976.

Schmidt, Gary E., "The Effectiveness of Large Lecture Recitation Sections Versus Small Group Classes and the Influence of Compulsory-Homework-and-Quizzes on the

Achievement and Attitudes of Calculus II Students," unpublished doctoral dissertation, Department of Education, Kansas State University, Manhattan, Kansas, 1973.