A STUDY OF THE INFLUENCE OF COMPULSORY HOMEWORK ON THE ACHIEVEMENT OF COLLEGE STUDENTS IN COLLEGE ALGEBRA

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PREFACE

The homework problem seems to be forever with us. The purpose of this study was to find experimental evidence comparing student achievement in a course requiring homework and one not requiring homework.

The writer is indebted to Dr. James H. Zant, Dr. David L. Weeks, Dr. W. Ware Marsden, Dr. W. Price Ewens, and Mrs. Helen M. Jones for their valuable guidance and assistance as members of the advisory committee. Special gratitude is expressed to Dr. Weeks for his personal interest and continued encouragement during the course of the study.

Special thanks are due the teachers who cooperated in the study. Without their assistance this study would not have been possible.

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CHAPTER I

THE PROBLEM

Introduction

The problem of homework is historic. Through the years, teachers at all levels have demanded some kind and amount of homework. However, since the beginning of the twentieth century, the trend has been to modify homework procedures and some schools have gone so far as to abolish such assignments.

Most writing on the subject, and there has been considerable, seems to be purely opinion. During the 36 years before May, 1964, the Educational Index lists 344 titles on home study. Of these 344 articles only 18 are reports of experimental research. Concerning the 280 titles listed before December, 1958 Goldstein states:

> Most of the articles are anecdotal or polemic and concern length and type of homework assignments. ... Only 17 are actual reports of experimental research on the homework problem.[1]

A survey was made by this writer of the titles of doctoral dissertations completed in Elementary and Secondary Mathematics from 1918 to 1960. During these years there were 410 dissertations with 187 in Secondary Mathematics, 186 in Elementary Mathematics, and 37 in the area of Teacher Training. None of these was a study of the homework problem.

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[1] Avram Goldstein, "Does Homework Help?" Elementary School Journal, Vol. 60 (January, 1960), pp. 212-224.

There is a vast divergence of opinion on the subject of homework which ranges from advocation of no extra work outside the classroom to the belief that schools should put more pressure on the students and considerable additional work should be done at home. The consensus seems to be in favor of some sort of homework as stated by Amatora:

> Although there are those who denounce all home assignments and will continue to denounce them, home study has had and continues to have a traditional place in our American Education System. ... it seems likely that some form of home study will be maintained (although it changes from time to time).[2]

However, Fine[3] says that the problem of assignments originated in 1904 when a German educator came to the conclusion that homework hindered rather then helped the school work of twelve- and thirteen-year-old pupils.

The fact that so many educators and laymen seem concerned about the homework problem and that the articles written are purely opinion indicates the need for experimental evidence on the subject. Harris has said:

> After reviewing some periodical literature of recent years, I found, as might be expected, most writing on the subject to be purely opinion and full of varieties. ... positive, negative, and neutral. Among all the writings expressing opinions and describing experiences, only a limited amount of real research is to be found.[4]

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[2]Sister Mary Amatora, "A Look at Homework," American School Board Journal, Vol. 137 (December, 1958), p. 22.

[3]Benjamin Fine, "No More Homework? The Pros and Cons," New York Times Magazine, January 13, 1956, pp. 16, 39, 41.

[4]Ben M. Harris, "What About Homework?" Texas Outlook, Vol. 43 (August, 1959), p. 38.

The point is made even more emphatically by Mulry when she says:

> ... greater study is needed before homework as an educational tool can be fully evaluated. I share the Journal's hope that the very lack of conclusive evidence presented here will stimulate the early development of sound research in this important field. It's high time for opinions to be replaced by facts.[5]

This study is an effort on the part of the author to supply some of the needed research. The study is concerned with the problem of finding the influence of required homework on achievement in a course in College Algebra.

Statement of the Problem

Stated in hypothetical form, the specific problem is that there exists no significant difference in achievement between students in a College Algebra class with required homework and those in a College Algebra class without required homework. In the study the results are investigated (a) for each specific teacher, and (b) averaged over all teachers.

Scope

This study involves a survey of the achievement of 432 students in 18 classes of variable size taught by 9 different teachers. These 9 teachers were teaching in 3 colleges and 2 universities located in Oklahoma and Missouri.[6] There were 2 classes for each of the teachers--one each semester, with homework required one semester and not required the other semester.

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[5]Jane Grant Mulry, "We Need Research on Homework!" National Educational Association Journal, Vol. 50 (April, 1961), p. 49.

[6]See Appendix A for complete listing of schools.

Limitations

Several limiting factors are apparent in this study and as a result certain restrictions must be placed on findings and conclusions of the study.

The total number of students involved is limited. When one considers the large number of students enrolled in College Algebra in any academic year, 432 seems to be a very small sample. The power of a test is defined as the probability of rejecting the null hypothesis when it is in fact false. Generally, the power of a statistical test increases with an increase in the size of the sample.

The study was further limited by the small number of teachers involved. This restricts the group to which inference can be made.

Difference in the ability or influence of the individual teachers was eliminated or minimized by experimental design. Control of this factor was the reason only teachers who were willing to teach with one of the methods being tested during the fall semester and then use the other method during the spring semester were asked to cooperate in the experiment.

Variable class size might be considered a limitation of the study. However, the statistical analysis should take care of this matter of unequal sample size. With regard to unequal sample size in the use of two independent samples, Siegel states:

> In this design the two samples may be obtained by either of two methods: (a) they may each be drawn at random from two populations, or (b) they may arise from the assignment at random of two treatments to the members of some sample whose origins are arbitrary. In either case it is not necessary

that the two samples be the same size.[7]

In reference to samples with different numbers of subjects Snedecor remarks:

> There is no necessity that the two groups be of the same size. In much experimentation it is inconvenient to provide equal numbers of individuals ....[8]

That other limitations exist is realized by the author. One must assume that variations exist in the students from class to class within and between schools. The only comparison made is in achievement on a standardized Algebra II Test which considers no other characteristic. No attempt is made to ascertain motivation of individual students, educational philosophy of individual teachers, educational philosophy of the separate schools, or the influence of geographical location. The writer assumes that the effect of these factors will be minimized by a statistical treatment of the collected data.

Purpose of the Study

When opinions are so definite and diverse as those with regard to the influence of home study, it seems important to support some opinion by research. Such evidence could be valuable to an administrator as he considers an overall policy for his school or to a teacher as he decides upon methods of instruction for his classes.

The purpose of the present study is twofold. The study will be undertaken to present experimental evidence in College Algebra which

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[7]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, (New York, 1956), p. 95.

[8]George W. Snedecor, Statistical Methods, (Ames, Iowa, 1946), p. 80.

might help to (1) determine whether or not student achievement in a College Algebra course in which homework is not required is equivalent to student achievement in a College Algebra course in which homework is required, and (2) provide information which might be used by other College Algebra teachers, teachers in other subjects, teachers at other levels in the school system, and administrators in making their evaluation of the influence of required homework on achievement.

It seems reasonable to assume that this study and others like it will cause some people to reconsider their opinion on the influence of required home study. It may even prompt some teachers to change their minds and revise their method of teaching.

Definition of Terms

There are several terms used throughout this study which may require classification for the reader. These terms are:

Required Homework. Study which is assigned by the teacher to be done by the student outside of class time. The work is to be graded regularly and used as 25 per cent of the final grade in the course.

Not Required Homework. Study outside of class is not required by the teacher and the grade in the course is determined without any consideration of work done outside of class.

Significant Difference or Statistically Significant. This means that a certain two quantities which are being compared differ by more than can reasonably be attributed to chance variation.

Analysis of Variance. This is essentially an arithmetic process for partitioning a total sum of squares into components associated with

recognized sources of variation.[9]

The "Analysis of Covariance Technique." Statistical adjustment for initial differences in the variables which provide a method of adjusting post-scores for students whose pre-scores were not equal. It makes use of the concepts of both analysis of variance and regression.

Overview of the Thesis

In Chapter I the writer has attempted to present the general idea of the study and to state the general hypothesis to be tested. An indication of the scope and limitations have been discussed along with the assumptions present in the statistical procedures.

The statement concerning the purpose of the study has attempted to present the need for the study. In addition it seeks to suggest the motivation of the writer in carrying out the survey.

A review of the related literature will be reported in Chapter II. Although no studies were found which treated the problem at the college level, a few were found which related to it at the elementary and secondary level.

Chapter III will be a detailed description of the experimental methods and procedures. This will include the specific hypothesis to be tested, the procedure used in gathering the data, and a discussion of the measuring instruments used.

In Chapter IV the writer will present the data and an analysis of the data. Models of the statistical methods used will be given to aid

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[9]Robert G. D. Steele and James H. Torrie, Principles and Procedures of Statistics, (New York, 1960), p. 99.

the reader in interpretation of the material presented. Tests of significance will be based on the F test which is a recognized statistical procedure. The value of F for this test will be obtained by use of the techniques of Analysis of Variance and Analysis of Covariance.

The content of Chapter V will be a statement of the findings and conclusions of this study.

CHAPTER II

REVIEW OF RELATED LITERATURE

After reviewing the periodical literature of recent years concerning home study the writer found, as might have been expected, most writing on the subject to be purely opinion and of great variety. Only a very limited amount of real research is reported in the literature. Stowe and Stewart seemingly came to the same conclusion in 1962 when they remarked,

> As a committee reviewed research on homework, it was discovered that no documented study had been made in this field since 1935.[1]

One is not certain as to the meaning placed on the word "documented" by Stowe and Stewart. Goldstein[2] refers to and reviews critically and in detail seventeen studies on homework which he says are "actual reports of experimental research." Eight of these seventeen studies date later than 1935 and five of these eight are in the decade beginning with 1950.

This author has surveyed all but five of the articles listed under the title of Home study in the Education Index from December, 1958 to May, 1964. Only one of the 59 articles surveyed is a report of

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[1]Elaine Stowe and Fred Stewart, "Home Study in the Elementary Schools," American School Board Journal, Vol. 144 (February, 1962), p. 20.

[2]Avram Goldstein, "Does Homework Help?" Elementary School Journal, Vol. 60 (January, 1960), pp. 212-224.

experimental research. Goldstein[3] has said that only seventeen of the 280 titles listed before December, 1958 are actual reports of research on homework. Thus, only eighteen of 344 articles listed as homestudy by Education Index since 1928 are reports of experimental research. Of these eighteen only one is a study at the college level; six pertain to grades 10 through 12; eight deal with grades 7 through 9; seven (including four of the eight relating to grades 7 through 9) relate to grades 5 and 6; and not one concerns grades 1 through 4.

The related literature will be presented in three sections. First, a review of the study which deals with the problem at the college level; second, those studies concerned with junior- and senior-high school students; and third, the studies pertaining to grades 5 and 6.

Study Related to College

In a study conducted with 351 students in four colleges Baker[4] used a brief questionnaire to get the opinions of the students concerning the effect of homework on their scholastic achievement. She was interested in ascertaining what their experience with assignments had been; which experiences helped and which hindered their scholastic achievement? The questionnaire was given in September, 1956 to 199 women and 152 men. The students were asked to check the one experience from a list of three in each of three categories which helped them most in any high school or college course. The three categories used were related to (1) when the assignment was given, (2) who decided on the amount of time to be spent

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[3] Ibid.

[4] Janet Bassett Baker, "College Students and Their Assignments," Journal of Educational Research, Vol. 54 (October, 1960), pp. 49-53.

on the assignment, and (3) whether it should be work in the text or in other material. The students were asked to check all experiences in a list of five which had hindered their progress.

The following conclusions are those reached by Baker:

1. College students want out-of-class work because their experiences teach them that it aids them to achieve a higher standard of work in college.
2. Students, for the most part, prefer their assignments to be given at the beginning of the semester; however, the instructor will have to be persistently checking on the assignment. Reports to class, tests, examinations, and interviews with students are a few of the checking devices.
3. Most of the students want the time that is to be devoted to an assignment to be left to them, for decisions, in which case the instructor will be obligated to check on the assignment. A friendly chat on the campus or a round-table discussion are suggestions for informal checks. It is doubtful whether a quarterly check and the final examination are adequate for checks.
4. College students prefer chapter assignments in many good texts; however, primary sources are also desired by the students. A variety of out-of-the-book assignments are necessary to individualize the student's home study which he does independently.
5. All annoyances which college students have hitherto experienced should be eradicated.
6. A syllabus, plus a variety of independent activities by students, will provide impetus to college students assuming independent study. Such a suggestive guide along with many informal conferences with the instructor, should help the students' learning.
7. Assignments are not regarded as meaningless chores, dreaded by both student and instructor. College assignments should so awaken students' interest that they promote scholarship, and if assignments do not, then something should be found to replace them.[5]

Studies Related to Junior and Senior High School

Ten of the investigations pertain primarily to junior-and senior-high school. Because of departmentalization in the secondary schools, each of these studies in almost every case is devoted to a single

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[5]Ibid.

academic subject. These studies present quite a variety of approaches and, although they are not exactly the same type of study as the one here reported on, they indicate the work that has been done.

Steiner[6] attempted to determine the value of homestudy assignments by measuring the gains made by pupils in achievement tests. This study was limited to finding the effect of homestudy assignments upon the standard test scores of seventh grade pupils in arithmetic and English. The experiment was conducted with 39 pupils entering the seventh grade and extended over the first semester of the school year 1933-34. The class was divided into two equivalent groups on the basis of mental ability and achievement tests in arithmetic and English. Half the pupils were required to do homework in English but not in arithmetic; for the other half the assignments were reversed. All the initial achievement tests or other forms of the same tests were used as post-test at the end of the semester to compare progress made by the two groups. The average of the increases in the scores of one group was compared with that of the other group on each test given.

The results at the end of the study showed clearly that the pupils in the group which had assigned homework in arithmetic made greater gains than the pupils in the non-homework group. The home study assignments in English did not have as great an effect on the English scores as was noticed in the group with homework in arithmetic.

An experiment was conducted with 292 pupils in the seventh grade of

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[6] M. A. Steiner, "Value of Home Study Assignments," School and Society, Vol. 50 (July, 1934), pp. 20-24.

seven parochial schools by Foran and Weber[7] during the school year 1935-36. All of the classes were given regularly assigned homework during one term and no homework during the other. Those with homework assigned during the first semester did not have it second semester and the pupils who did not have homework during the first semester were given assignments during the second semester. The general intelligence of the two groups was approximately the same as was the average arithmetic score. During one semester the non-homework group gained (on the average) more than the homework group while the results were reversed the other semester.

Examination of the gains made by the seven schools revealed equally large gains under both programs although the accumulated gain favors the group having home assignments. The gains are not significant in favor of either method. However, the tendency favors homework. Homework does not appear to be an important factor in achievement among seventh grade pupils in arithmetic if one relies on this study.

In 1946 Anderson[8] reported on a study conducted with 58 pupils in the eighth grade. The pupils were divided into two groups by matching them on the basis of results on the Otis Self-Administering Tests of Mental Ability, Intermediate Form A. The study covered three subjects; English, social studies, and mathematics. The two groups met during consecutive periods in each subject and both groups had the same teacher for

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[7] T. G. Foran and Sister M. M. Weber, "An Experimental Study of the Relation of Homework to Achievement in Arithmetic," Mathematics Teacher, Vol. 32 (May, 1939), pp. 212-214.

[8] W. E. Anderson, "An Attempt Through the Use of Experimental Techniques to Determine the Effect of Home Assignments Upon Scholastic Success," Journal of Educational Research, Vol. 40 (October, 1946), pp. 141-143.

a particular subject. The teachers attempted to keep all factors except homework the same for both groups. The experimenter found the mean, standard deviation, and standard difference of the means of the scores of all students in all three subjects at the end of each test period. The results favor the home study group. The differences were reportedly significant but no level of significance was given. On an analysis of the mean average scores of each of the five unit tests the advantage proves favorable to the homework group.

Anderson feels that the following conclusions are justified on the basis of his study:

1. Home study properly assigned and evaluated so far as it refers to the pupils in this experiment is an aid in improving scholarship.
2. Home study is equally valuable to pupils of average intelligence in English, social studies, and mathematics.
3. On the basis of this study non-home study pupils are sporadic in their achievements.
4. The brighter pupils in the non-home study group as a whole did not gain as much as those in the home study group.
5. The average and dull pupils of the non-home study group were much less successful than those in the home study group.[9]

McGill[10] had his project accepted for the doctorate at New York University. It was his objective to find out whether homework had any effect on: a) achievement in social studies abilities, and b) achievement in economics or American history and government. The study was conducted with sixteen classes in one school in New York City. There were eight classes in twelfth grade economics and eight classes in eleventh grade American history and government. The study began in March, 1947 and ended in February, 1948. There were two teachers in economics and

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[9] Ibid.

[10] J. V. McGill, "How Valuable is Homework " High Points, Vol. 32 (September, 1950), pp. 48-53.

two teachers in history and government.

Two groups were formed by matching the students according to their score on Cooperative Tests of Social Studies Abilities, Form Q and by I.Q. as determined by Terman-McNemar Test of Mental Ability. The study was conducted with 185 very closely matched pairs. At the end of the respective semesters all pupils took the Cooperative Test of Social Studies Abilities, Form Q while those in history and government also took Form S of Cooperative Test in American History and those in economics took Form P of Cooperative Economics Test.

The results show no statistical significance in the difference of the means of any of the four groups on the social studies test. However, the mean of the non-homework group was higher than the mean of the group with homework. Homework classes of both economics groups had higher mean scores than the non-homework classes on the economics test. However, in history the results reversed in the two semesters.

McGill reported the conclusion of his study in this manner:

1. The critical ratios obtained in the experiment did not furnish sufficient evidence to claim that one method was conclusively superior to the other. The differences between the paired members of experimental and control groups were in no instance statistically significant.
2. Any claim made for eliminating homework in the field of social-studies abilities must be based on consistency rather than on reliability. In examining each group individually three "t's" of +2.35, +2.54, and +4.63 were obtained by experimental (non-homework) classes in groups A, C, and E, respectively. All three were statistically significant in the direction of non-homework classes. Further experimenting might change a consistent difference into a significant one.
3. The results obtained in measuring ability in the specific subjects of economics and American history and government warranted no claim for significance. Not only did the results in groups G and H, combined, run counter to the trend but the highest "t," +1.98, was in the direction of the non-homework (experimental) class.
4. In all other sub problems, the results demonstrated that neither method of lesson preparation (homework or non-homework) brought about a reliable change in pupils during

the course of the experiment.[11]

Another experiment concerned with the value of homework in high school economics was conducted by Schneider.[12] In this study only two classes were used. The classes were roughly comparable; 28 pupils in one and 24 in the other, the average I.Q. in one was 104 and in the other it was 102, the I.Q. range was 132 to 77 compared to 121 to 72 in the other. The normal number of homework assignments were given in the normal way to one class and no homework of any kind in the other. There was no significant difference in the test results of the two classes on a departmental mid-term test.

Schneider says:

> From a qualitative point of view my reactions were about as follows:
> 1. The class without homework probably felt the subject was less important since it didn't have the traditional burden to bear. One way to overcome this feeling is to motivate constantly the approach to any phase of the lesson under consideration, and to give tests frequently.
> 2. Pupil expressions indirectly reported to me were that the teacher seemed to work much harder than others did who gave homework. I did experience a definite sense of urgency with this class.
> 3. There was greater opportunity to use directed study and open book techniques in the class that had no homework.
> 4. If it is possible to establish generally the teaching of economics classes without homework of the traditional type, then many opportunities will present themselves for greater student research.[13]

An experiment which was limited to a four week period late in the semester was conducted by Schain.[14] One class in American history was

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[11] Ibid.

[12] Samuel Schneider, "An Experiment of the Value of Homework," High Points, Vol. 35 (April, 1953), pp. 18-19.

[13] Ibid.

[14] Robert L. Schain, "Another Homework Study in the Social Studies," High Points, Vol. 36 (February, 1954), pp. 5-12.

used for both control and experimental groups. The class was divided into two groups by matching pairs on I.Q. and previous social studies marks. For a period of two weeks one group was given an assignment each day while the other group had no assignment. After two weeks the groups were reversed for two weeks. The two objectives of the experiment were to find if students felt more secure by doing homework and to see if they learned more. The report gives no information about the form of the short-answer quizzes or the full-period essay test used to measure achievement.

Following are some of the test results as reported by Schain:

> 1. In daily short-answer tests, the homework group in the first half of the experiment averaged 72.5 per cent, while the non-homework group averaged only 65 per cent. When the groups were reversed, the group now doing homework averaged 78.8 per cent while the non-homework group achieved at 72.5 per cent. There was only one instance in the whole sequence of short-answer tests where the non-homework group had a better daily average than did the prepared group. This might be explained by the unusual difficulty of the daily test which produced poor results from both the prepared and the unprepared groups. On the other hand, the homework group did better than the other groups in the other daily tests, exceeding the unprepared group with averages from 1 point to 19 points each day.
>
> 2. For the full-period essay test after the first part of the experiment, the homework group scored an average of 84.9 per cent, while the non-homework group averaged 68 per cent.
>
> 3. The essay test for the second part, with the groups reversed found the now unprepared students reaching an average of 74.7 per cent compared to the homework group which scored an average of 83 per cent.
>
> 4. An analysis of the results showed that the brighter students did well whether or not they did homework, although they scored somewhat higher marks when they were in the homework group. The poorer students were absolutely lost when they did no homework, while they did better when they did homework. The average student scored much better marks while in the homework group.
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> In summary, it seems that homework does contribute to the learning process, especially to the "average" student and the slower learner.[15]

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[15] Ibid.

At the University High School, University of Illinois, Hines[16] carried out a study with two classes in Plane Geometry. The two classes were formed by the technique of matched pairs using chronological age, intelligence quotient and point averages for two semesters of beginning algebra. Sixteen of nineteen pairs who began the study under two teachers were used for final scoring. A pre-test in plane geometry indicated very little knowledge of plane geometry. The same text was used by both teachers and they agreed to follow the text closely. The two classes met at the same time of day and both lasted for the usual school year. They took the same eight unit tests and seven cumulative review tests which were of the objective type and prepared by the high school mathematics staff. At the end of the year they took Cooperative Plane Geometry Test, Form N. Every one of 17 comparisons favored the homework class and nine of the differences of means were statistically significant at the 5 per cent level.

The conclusions were stated by Hines as follows:

1. Out-of-class study, usually written work, increases achievement in plane geometry.
2. The differences in achievement tend to be cumulative.
3. Differences tended to be slightly greater on cumulative review tests than on unit tests covering recent material.
4. If a traditional grading system were used --- A, B, C, D, E, --- and if students were graded only on the tests reported here, home study would increase the grade of the average student by a letter.[17]

There were three other studies in the junior and senior high range. This writer was unable to review these but includes here a critical review of each by Goldstein.

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[16]Vynce A. Hines, "Homework and Achievement in Plane Geometry," Mathematics Teacher, Vol. 50 (January, 1957), pp. 27-29.

[17]Ibid.

Montgomery conducted a similar experiment (refers to Steiner) with 30 pairs of pupils in Grades 7 through 9 in a West Virginia mining community of low economic status. The design differed only slightly from that of the study just described. One group was given homework in English but no homework in arithmetic. The other group was given homework in arithmetic but no homework in English. After one term the groups were crossed over and the experiment was continued until the end of the year. The mean intelligence quotient of the entire group was only 87. The overall data showed a slight advantage for homework in arithmetic and for no homework in English, neither result was statistically significant. The ninth grade and the groups with highest intelligence quotients showed "a decided result in favor of home study" in arithmetic but in favor of no homework in English. The raw data indicate so great a variability in achievement gains per pupil in both subjects that none but the grossest effects of homework or no homework could possibly have been established.

Abramowitz conducted an experiment of a few weeks' duration in 3 Spanish classes. Two had regular homework. The third was given assignments, but the students did not hand in any written work. The same mid-term test was given to all 3 classes. Average marks are presented for this test and also for the previous term. The marks slightly favor the regular homework classes. The author concludes that "the negligible difference does not seem to warrant the extra time and effort" on homework, but the crudity of the experimental design would seem to rule out any definite conclusion.

Sutcliffe and Canham conducted a rather elaborate experiment with fifty boys in a British secondary school, to see whether academic achievement was affected by substituting supervised study for home study in all subjects. The outcome was favorable to the home study group in history, geography, and French; to the supervised-study group in English; and to neither group in mathematics and physics. Serious weaknesses in the experimental design, however, invalidate most of the conclusions. In English the supervised-study group actually had as much home study as supervised study. And taking all the subjects together, the home study group spent five hours more in total weekly preparation than the supervised-study group did.[18]

Studies With Fifth and Sixth Grades

The seven investigations in grades 5 and 6 are as varied as those in junior-and senior-high school concerning length of the experiment, size of sample, and experimental design. However, two of these are

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[18]Goldstein, p. 218.

probably the best-designed and most carefully done of all the studies reviewed.

Cooke and Brown[19] sought to determine the relationship between the amount of home study and school achievement. Almost a thousand pupils in grades 5 through 8 in one Birmingham, Alabama school were tested at the beginning and end of a three month period to show progress in reading, literature, history and arithmetic. Each student filled out a form each day indicating the number of minutes of homework on each subject. The data were treated statistically through partial and multiple correlation. It seems that this would give a correlation between length of time doing homework and achievement in the aforementioned subjects. The authors did not present the data and gave the following conclusion:

> The results are not given here because they have no particular significance. In terms of the data in this study, it seems there is nothing to be gained, by way of achievement, in requiring elementary school pupils to study at home.[20]

A comparison between homework and supervised study was made with twenty-six matched pairs of sixth grade pupils in Columbia, Missouri. Rosenstengel and Turner[21] matched two groups on the basis of chronological age, mental age, and educational age. The experiment was conducted in health class and the two groups had the same teacher. The same test was used as pre-test and post-test. One group did homework

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[19]Dennis H. Cooke and Gregory B. Brown, Jr., "Home Study Has Many Angles," Journal of Education, Vol. 118 (October, 1938), pp. 408-410.

[20]Ibid.

[21]W. E. Rosenstengel and Charles Turner, "Supervised School Study vs. Home Study," American School Board Journal, Vol. 92 (April, 1936), p. 42.

and the other did no homework but had a 15-minute supervised study period at school. This was a short duration experiment covering only two units. Gain was measured by teacher made objective tests on each unit and then total gain by the post-test.

The following conclusions were stated by the investigators:

1. The experimental group (the group which did no homework) made a greater average gain on the two units of work than the control group (the group which did homework). The experimental group averaged 7.1 points or 8.6 per cent more gain than the control group.
2. The results from this experiment would tend to indicate that elementary students would profit more by having supervised study than doing homework and no supervised study.[22]

Another study which compared homework and supervised study was conducted by Cooke and King[23] with 156 pupils in fifth and sixth grade. Matched groups were formed by the usual procedures. One group did one to one and a half hours of homework each day while the other group did no homework but instead did 40-minutes of supervised study. Different forms of the same achievement test were given at the beginning of the experiment, at the end of the first semester, and at the end of the second semester. The authors state the following general conclusions after comparing the gains made by each group in various subjects:

1. Home study in these fifth and sixth grades was of no more value to the student than supervised study at school. The implication, therefore, is that supervised study should be emphasized regardless of whether or not home study is used. Possibly both methods should be used to some degree.
2. Home study in reading was of little value, while both grades made slight gains in favor of home study.
3. Home study in geography was of no significant value.
4. Slight gains were made by both grades in favor of home study in literature. This was probably due to the fact that many

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[22] Ibid.

[23] Dennis H. Cooke and Lester King, "Should Children Study at Home?" American School Board Journal, Vol. 98 (February, 1939), pp. 49-50.

library books were read at home which had literary value.
5. Home study in science was of no value to the sixth grade and probably harmful to the fifth grade.
6. Home study in history was beneficial to both grades.
7. There was little or no value in home study in arithmetic. Insignificant gain was made in favor of home study in arithmetic problems and in favor of no home study in arithmetic computation.
8. Home study in English was of no value for sixth grade, and was probably harmful to the fifth grade.
9. Home study was of more value in literature, history, and arithmetic problems than in other subjects.[24]

Vincent[25] conducted a twenty-week study in geography, arithmetic, and English. The research was confined to grades five and six and was done on an equivalent group basis. The details are vague but it seems that the pupils were grouped according to general ability based on the teachers' judgement. The same teacher had charge of both groups, homework and no homework, in every case. No group was left out entirely. When homework was assigned in geography to one group, the other group had homework in arithmetic and likewise for English. The investigator concluded that it probably did not pay to give homework and in some instances it appeared to be harmful.

A well-designed and carefully executed experiment was conducted in New York City during the second semester of the 1934-35 school year by Di Napoli.[26] A random sampling of the city was obtained by using six schools in various types of communities. 1200 children in 5B and 7B classes formed the basis for the study. Out of the 1200, 398 matched

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[24] Ibid.

[25] H. D. Vincent, "An Experimental Test of the Value of Homework in Grades Five and Six," National Elementary Principal, Vol. 16 (June, 1937), pp. 199-203.

[26] Peter J. Di Napoli, "Homework in New York City Elementary Schools," Contributions to Education, No. 719, New York: Teachers College, Columbia University, 1937.

pairs were obtained. The matching was on the basis of chronological age, Otis-Test scores, and as far as possible total average initial score on the Metropolitan Achievement Tests.

In the compulsory-homework classes regular daily assignments were given. Voluntary-homework classes were not required to do homework but when a pupil did, the work was taken up. The curricula was the same for both groups in each school including use of the same texts. In each school the two groups had the same teacher, same methods of instruction, and school environment was not altered. Except for the difference of compulsory-homework the usual routine was followed in all instances.

The Metropolitan Achievement Tests were administered again during the last two weeks of the semester. Comparisons were made on the basis of statistical differences between the mean gains. In the fifth grade, the gains on these test scores favored the compulsory-homework group in all subjects except Arithmetic Fundamentals and the total average gain in the nine subjects was statistically significant at the 5 per cent level. In the seventh grade, the gains varied greatly and seemed to favor voluntary-homework slightly.

Di Napoli reached two general conclusions which follow:

1. Compulsory homework in the fifth grade, male and female, favors achievement as measured by a battery of standardized tests and there is a tendency for this difference to approach significance.
2. Voluntary homework in the seventh grade, male and female, favors achievement as measured by a battery of standardized tests, but the differences are so slight as to be insignificant. Certainly from these data one cannot agree that either compulsory or voluntary homework leads to greater academic accomplishment in the seventh grade.[27]

The most elaborate study reported was conducted by Carmichael

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[27]Ibid., p. 41.

and reported by Carmichael and Crawford.[28] This study was based on a careful annual measurement of the achievement of all the children in Grades five through eight in the El Segundo, California grammar school over a three-year period with home study, followed by a three-year period without home work for other pupils. Carmichael measured the results each year by means of the Stanford Achievement Test. Grade-placement norms were compared, not only on the basis of composite scores for the whole test but also on the basis of the scores for the different parts of the test that were constant during the six year period.

There seemingly is no significant difference between achievement in the three years with homework and the three years without homework. The net difference ranges from 8 to 13 days, according to the basis of calculation and is to be interpreted as a loss of 8 to 13 days in an average of two years of school time. This loss is obviously too small to be considered significant. These figures are based on the average of three yearly testings with home study and the average of three yearly testings without home study.

Carmichael assembled some data regarding the effects of homework in grades V-VIII on high school marks of the graduates of El Segundo Grammar School after home study in the grammar school was abolished. The drop was not caused by a general drop in the high-school marks because a check on this point showed the marks to be nearly constant during the six year period.

The slump evidently resulted from differences in attitudes or habits of work. The pupils who had no home study for a period of time

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[28] C. C. Crawford and J. A. Carmichael, "The Value of Home Study," Elementary School Journal, Vol. 38 (November, 1937), pp. 194-200.

apparently had difficulty in getting down to it again when they entered high school.

The lowered marks of the pupils who had no home study might conceivably result, not from their lesser mastery of high-school subjects, but from lack of conformity to rules and assignments with respect to the time of handing in papers.

Crawford and Carmichael give this summary:

> This study revealed no significant difference in scores on the Stanford Achievement Test in Grades V-VIII during three years with home study and three years after home study was abolished. The pupils without home study, however, although equally well prepared in subject matter, suffered a drop in high-school marks to the extent of 0.41 of a mark, which was highly significant from a statistical viewpoint. This finding suggests strongly the interpretation that evening leisure once enjoyed is hard to give up or that, if homestudy is once abolished, the pupil has difficulty in returning to it.[29]

Goldstein makes the following comments about a study by Teahan which this writer was unable to review:

> Teahan set up matched groups of sixth-, seventh-, and eighth-graders for an arithmetic study in a New Jersey school. The experiment is only sketchily described, and the design details are left unclear. Homework and non-homework groups were tested after 115 days. The median scores were the same in both groups. The author concluded that homework is of no value in promoting achievement in arithmetic.[30]

Summary

Of the many urgent problems that our schools face at the present time homework is one of increasing concern to all people associated with education. Almost every month one reads an article voicing opinions on the beneficial or the detrimental effects of homework.

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[29] Ibid.

[30] Goldstein, p. 217.

The results of seventeen experimental studies have been reported here. There seems to be no concensus of opinion as one considers the conclusions reached by these investigators. Some investigators build a weak case in support of homework whereas other investigators feel that they have shown the folly of requiring children to study at home.

The absence of general agreement on the subject of homework in the studies reviewed is taken by the author as evidence supporting the need for the present study. Also, the suggestion that homework may be more important at some grade levels than others and in some subjects than others supports the proposed research using an algebra course at the college level as a basis for study.

CHAPTER III

EXPERIMENTAL METHODS AND PROCEDURES

As stated previously, the purpose of this study is to investigate the influence of required home study on achievement in College Algebra. Information concerning the background of the study, the testing instruments used, and the statistical methods employed in exploring the problem will be given in this chapter.

General Design

Several specific decisions related to the problem had to be made in order to conduct the aforementioned investigation. These were:

1. Formulation of the hypothesis to be tested.
2. Selection of the tests to be used in measuring the achievement of the students.
3. Location of teachers willing to cooperate in the experiment.
4. Collection of the data at the beginning and at the end of both the first and second semesters.
5. Statistical procedures best fitted to interpret the collected data had to be determined.

This chapter will be devoted to a discussion of the five decisions listed above.

Hypothesis To Be Tested

The specific hypothesis to be tested is:

There is no significant difference in achievement between students in a College Algebra class with required homework and those in a College Algebra class without required homework.

Tests Used In The Study

Two tests were used to provide data needed for the study. These tests were Form A and Form B of The New Cooperative Mathematics Tests, Algebra II. The writer tried, but was unable, to find a College Algebra test to give as the post-test. In a letter to the author, Miss Mary K. Reeber of The Cooperative Test Division of Educational Testing Service said,

> "Our Algebra III test, specifically designed to measure achievement in college algebra, will not be distributed until the spring of 1964 and, unfortunately, pre-publication copies are not available for experimental use. Moreover, I have checked with our Evaluation and Advisory Service for information on an Algebra III test available from other sources, and have found that none is currently available."

The Cooperative Test Division of Educational Testing Service gives the following information concerning the New Cooperative Mathematics Tests:

> Some of the newer emphases in language and content can be found in these tests, but in the main, important aspects of traditional mathematics continue to be measured. Students in both traditional and new courses will find the tests stimulating and understandable. Unlike tests which measure routine manipulation of symbols or the recall of specific information, these tests emphasize the student's understanding of mathematics ideas and his ability to reason with insight.
>
> When possible, a few of the major shifts in the mathematics curriculum have been represented in these tests. CTD hopes that the decisions and compromises that have been made about content have produced tests which will be of maximum value

> to the largest number of schools in this difficult period of transition and ferment in the mathematics curriculum.
>
> The data presented in this booklet are based on small, selected samples of students tested in May, 1961. These data will enable users of the tests to have some preliminary information about test characteristics and to make score comparisons with other reference groups in addition to local ones.
>
> For the May, 1961 administrations, the ETS staff selected the suburban and rural high schools and the cities that were invited to participate. Form A, Algebra II was administered to 1343 students, while Form B was given to 1330 students, in the same 20 schools in 15 states.
>
> The test requires 40 minutes of testing time and can be administered in a 45 minute period. Reliabilities were computed by Kuder-Richardson Formula 20; Form A has a reliability of .82 and Form B has a reliability of .83.[1]

Cooperating Teachers

The writer contacted, either personally or by mail, the Head of the Department of Mathematics in seventeen colleges and universities located in Oklahoma and the neighboring states. This contact included an outline of the experiment and invited the participation of all interested teachers in the department. Some of the people contacted did not respond in any manner to the letter they received. Several others expressed an interest, but inability to cooperate because they did not offer College Algebra as a separate course or because they did not offer it each semester.

A total of nine teachers from five colleges and universities did agree to cooperate in the study. They were willing to follow whatever instructions they received from the author to carry out the investigation.

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[1] Cooperative Mathematics Tests (Interpretive Booklet), Cooperative Test Division, Educational Testing Service, Princeton, 1962.

Collection Of The Data

The experimental students included in the study were those students enrolled during the fall or spring semester of 1963-1964 in College Algebra classes taught by teachers who had agreed to participate in the study.

In September, 1963, at the beginning of the fall semester, and in January, 1964, at the beginning of the spring semester, Form A, Cooperative Mathematics Tests, Algebra II was given to all students in the experimental classes. The data obtained was used as the measure of achievement attained by each student in Algebra before taking College Algebra. Form B of the same test was administered to all students in the experimental classes, in January, at the end of the fall semester, and in May, at the end of the spring semester. The scores on Form B were used as the measure of achievement of each student in Algebra at the conclusion of a course in College Algebra. In order to match as nearly as possible the required homework class with the non-homework class the teachers were asked to give the tests on corresponding dates in the two semesters.

Each teacher decided independently whether to require homework during the fall semester or during the spring semester. However, in each case he made it clear to the students at the beginning of the semester that homework would or would not be required and considered in determination of the final grade in the course.

The distribution of the students involved in this study is shown in Table I.

TABLE I

CLASSIFICATION OF STUDENTS INCLUDED IN THE STUDY BY TYPE OF INSTRUCTION AND TEACHER

Method	Teacher									Total
	T_1[x]	T_2[x]	T_3	T_4[x]	T_5[x]	T_6[x]	T_7	T_8	T_9	
Homework Required (R)	28	17	21	27	38	29	42	27	12	241
Homework Not Required (N)	23	7	10	22	24	21	43	21	20	191
Total for each Teacher	51	24	31	49	62	50	85	48	32	432

[x]Teachers who required homework during fall semester.

Five of the teachers, involving 236 students, required homework during the fall semester and the other four, involving 196 students, required it during the spring semester. There was no attempt to determine whether or not each teacher had a preference with regard to required home study.

Statistical Methods

The problem was to test the hypothesis concerned with two independent samples which arose from the assignment of two distinct methods (requiring homework or not requiring homework) to the members of the population. In such a case it is not necessary that the two samples be of the same size.[2] This is extremely important in the present study because it is almost impossible to find teachers who have classes exactly the same size during fall and spring semesters.

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[2]Sidney Siegel, Non-parametric Statistics for the Behavioral Sciences, (New York, 1956), p. 95.

Both a parametric and a non-parametric method of statistical analysis were selected by the investigator for analysis of the differences in achievement. The analysis of variance (the F-test) was the parametric technique used and the Mann-Whitney U Test was chosen as the non-parametric method. Referring to the Mann-Whitney U Test Siegel says:

> This is one of the most powerful of the non-parametric tests, and it is a most useful alternative to the parametric t test when the researcher wishes to avoid the t test's assumptions, or when the measurement in the research is weaker than interval scaling.[3]

A covariance analysis was applied to the raw data with the pretest score as the covariate. This method was used to determine the significance of the difference in effect of the two methods for each teacher and then for the entire set of data.

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[3]Ibid., p. 116.

CHAPTER IV

RESULTS OF THE STUDY

It was the objective of this study to find experimental evidence which would help determine whether student achievement in College Algebra is greater when homework is required and used in determining the final grade than when no homework is required. The statistical data are presented in tabular form and the results as indicated by the analyses of variance and covariance and the Mann-Whitney U test are given along with mathematical models.

Difference Analysis

An analysis of variance of student achievement was run for each teacher when the students were classified under two groups (methods) for instruction. Student achievement in this instance was measured as the difference in pre-test and post-test scores on two forms of the same standardized test. The teacher is a variable which is very difficult to control in educational research. In this study each teacher used two homework methods, required homework and not required homework, thus minimizing the teacher factor in the experiment.

A summary of the information needed for the separate analyses of variance is shown in Table II.[1] An analysis of variance was used to

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[1]The raw data is tabulated in Appendix B.

TABLE II

SUM OF DIFFERENCES AND SUM OF SQUARES OF DIFFERENCES

BY TEACHER AND BY METHOD

	Teacher									
	T_1		T_2		T_3		T_4		T_5	
	R	N	R	N	R	N	R	N	R	N
Number of Students	28	23	17	7	21	10	27	22	38	24
Sum of Differences	113	133	120	63	143	69	192	141	171	40
Sum of Squares of Differences	1027	1181	1560	697	1365	573	2086	1429	1613	606

	T_6		T_7		T_8		T_9	
	R	N	R	N	R	N	R	N
Number of Students	26	21	42	43	27	21	12	20
Sum of Differences	99	62	346	251	195	258	95	106
Sum of Squares of Differences	754	1088	4108	2637	2331	3834	1047	908

R - Required Homework N - Not Required Homework

determine whether or not there was a significant difference in achievement, as measured by differences, of the students taught by each teacher using the two methods. The results of this analysis of variance for Teacher 1 are given in Table III.

TABLE III

ANALYSIS OF VARIANCE FOR THE DIFFERENCES IN ACHIEVEMENT SCORES ON FORM A AND FORM B OF STUDENTS STUDYING WITH TEACHER 1

Source of Variation	Degrees of Freedom	Sum of Square	Mean Square	F-Ratio
Total	50	1021.41		
Methods	1	38.54	38.54	1.92
Within	49	982.87	20.06	

This analysis of variance revealed that the difference in algebraic achievement between the two methods of instruction considered in the study was, when considering teacher 1, statistically significant at the 85 per cent level. That is, the probability of observing an F-ratio less than 1.92 under these conditions is .85.

In work of this nature it is usual to establish an acceptable confidence level for testing significance. The levels most frequently selected are 5 per cent and 1 per cent or, equivalently, 95 per cent and 99 per cent. In this study the significance level for each test was determined and is stated in preference to merely saying significant or not significant at an established level of confidence. The writer believes that additional information is conveyed to the reader by this method. For example, both 60 per cent and 94 per cent would be classed

as not significant at an established 95 per cent level of confidence. However, as reported in this study, one knows whether the level of significance is 60 per cent or 94 per cent.

With reference to significance level Kempthorne says,

> The evaluation of levels of significance is highly important, but the tendency for uncritical use of 5 per cent and 1 per cent levels should be avoided.[2]

In order to make meaningful the level at which a test is significant, the significance level can be thought of as a measure of the strength of evidence against the null hypothesis.

Analyses of variance were completed for the other eight teachers and the F-ratio values and significance level for each are recorded in Table IV, page 37. One notices that the significance level ranges from 4 per cent to 99.5 per cent. In some instances, the significance levels are approximate due to linear interpolation in the F tables available.

An analysis of variance was also completed for the entire set of data. There were 241 students in the homework group and 191 in the non-homework group. This analysis required use of the Abbreviated Doolittle Technique[3] which was used to find the Sum of Squares for Methods. The results of this analysis are shown in Table V, page 38. With 8 degrees of freedom in the numerator and 414 degrees of freedom in the denominator an F-ratio would be less than 3.07 more than 99.5 per cent of the time. Interaction between the method of instruction (homework or non-homework) and the teacher is statistically significant

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[2] Oscar Kempthorne, The Design and Analysis of Experiments, (New York, 1952), p. 12.

[3] Franklin A. Graybill, An Introduction to Linear Statistical Models, (New York, 1961), pp. 298-303.

TABLE IV

F-RATIO VALUES AND SIGNIFICANCE LEVEL

FOR TEACHERS T_2 THROUGH T_9

Teacher	F-Ratio With Degrees of Freedom		Significance Level
T_2	(1,22)	0.49	.53
T_3	(1,29)	0.003	.04
T_4	(1,47)	0.23	.42
T_5	(1,60)	5.12^{x}	.975
T_6	(1,48)	0.10	.29
T_7	(1,83)	4.18^{x}	.965
T_8	(1,46)	8.78^{xx}	.995
T_9	(1,30)	2.40	.85

^{x}Significant at .05 level of confidence.
^{xx}Significant at .01 level of confidence.

at the 99.5 per cent level. This indicates that whether or not homework should be required varies with the teacher. When averaged over all teachers in the experiment, the difference in achievement between the two methods has a significance level of less than 10 per cent. Thus, for a .05 confidence level there is no significant difference.

The Mann-Whitney U Test was used as a second method to test whether or not there was a difference in achievement by the homework group and the non-homework group. This test is often used as an alternative to the parametric t test or F test. However, this investigator is using it as supporting evidence for the F test in each of the analyses of variance.

TABLE V

ANALYSIS OF VARIANCE OF THE DIFFERENCES OF ACHIEVEMENT SCORES ON FORM A AND FORM B OF NEW COOPERATIVE MATHEMATICS TESTS, ALGEBRA II FOR ALL STUDENTS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio
Total	431	13222.94		
Teachers	8	1650.03		
Methods in Teachers	9	660.60		
Methods	1	12.94	12.94	0.49
Methods by Teachers	8	647.66	80.96	3.07[xx]
Within Teachers	414	10912.33	26.36	

[xx]Significant at .01 level of confidence.

Table VI, page 39, contains the difference in scores of the students in the two classes taught by Teacher 1 together with the rank of each in the combined group. These data are used to find U where $U = n_1 n_2 + n_1 \frac{(n_1+1)}{2} - R_1$. In this particular case U = 245.5. Knowing U, we then find the value of z by substituting in the formula

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\frac{(n_1)(n_2)(n_1+n_2+1)}{12}}}.$$

For teacher 1, z = 1.448. Referring to a z table the investigator found the probability of $z \leq 1.448$ to be .85. This is the same probability or significance level found by analysis of variance.

TABLE VI

DIFFERENCES OF PRE-TEST AND POST-TEST SCORES FOR STUDENTS IN REQUIRED HOMEWORK CLASS AND NOT REQUIRED HOMEWORK CLASS TAUGHT BY TEACHER 1

Student	Difference	Rank	Student	Difference	Rank
1	12	49	1	14	50.5
2	10	46.5	2	14	50.5
3	10	46.5	3	11	48
4	8	41	4	9	45
5	8	41	5	8	41
6	8	41	6	8	41
7	7	35.5	7	8	41
8	7	35.5	8	8	41
9	7	35.5	9	7	35.5
10	6	30.5	10	6	30.5
11	6	30.5	11	6	30.5
12	5	25.5	12	6	30.5
13	4	21	13	6	30.5
14	4	21	14	5	25.5
15	4	21	15	5	25.5
16	3	16	16	5	25.5
17	3	16	17	4	21
18	3	16	18	4	21
19	3	16	19	3	16
20	2	11.5	20	1	8.5
21	2	11.5	21	1	8.5
22	2	11.5	22	-2	5.5
23	2	11.5	23	-4	2
24	0	7	$n_1 = 23$		$R_1 = 674.5$
25	-2	5.5			
26	-3	3.5			
27	-3	3.5			
28	-5	1			
$n_2 = 28$		$R_2 = 651.5$			

The results of the Mann-Whitney U Test for the data related to the other eight teachers is summarized in Table VII, page 40.

TABLE VII

VALUES OF U, Z, AND SIGNIFICANCE LEVEL FOR METHODS IN TEACHERS T_2 THROUGH T_9

Teacher	U	Z	Significance Level in Per Cent
T_2	46.5	0.774	56
T_3	106	0.042	3
T_4	339.5	0.933	65
T_5	623	2.413^{x}	97.5
T_6	320.5	0.314	25
T_7	644.5	2.272^{x}	98
T_8	113.5	3.533^{xx}	100
T_9	88.5	1.226	78

^{x}Significant at .05 level of confidence.
^{xx}Significant at .01 level of confidence.

One will note a definite agreement between the results in Table VII and those shown in Table IV. Where there seems to be a difference in the significance levels, the difference is probably due to the use of linear interpolation over a long interval in the F-Ratio Tables.

In this "difference" analysis the writer has assumed a linear model. The mathematical description or equation of the model because of disproportionate subclass numbers and interaction is $y_{ijk} = m + \tau_i + \mu_j + (\mu\tau)_{ij} + \beta_{ij}x_{ijk} + e_{ijk}$. The method of fitting constants requires estimation of m, the τ_i's, the μ_j's and the $(\mu\tau)_{ij}$'s such that the residual sum of squares is a minimum. y_{ijk} is post-test score and

x_{ijk} is pre-test score for the same student. The subscript i refers to method and has values 1 and 2; j refers to teacher and has values 1, 2, ···, 9; k refers to students in a class and varies from 1 to n_{ij}. β_{ij} is the slope of the regression line and is taken to be 1 for every i and j in the difference analysis. This seems to be a bold assumption because it implies that the expected gain is the same for all students. That is, that a student with a high pre-test score would be expected to gain as much as one with a low pre-test score. Perhaps this is unrealistic due to the difference in opportunity to gain of a student with pre-test score near the maximum possible score of 40 and one with a lower score.

Covariance Analysis

The analysis of covariance makes use of the concepts of both regression and analysis of variance. This study considers only linear covariance. Steel and Torrie say that the most important uses of covariance analysis are:

1. To assist in the interpretation of data, especially with regard to the nature of treatment effects.
2. To partition a total covariance or sum of cross products into component parts.
3. To control error and increase precision.
4. To adjust treatment means of the dependent variable for differences in sets of values of corresponding independent variables.
5. To estimate missing data.[4]

It is the intention of this writer to use it as suggested in uses 3 and 4 due to the fact that variation in the dependent variable y, which is the post-test score, is partly attributable to variation in the

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[4]Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, (New York, 1960), p. 305.

independent variable x, the pre-test score.

Upon deciding that the difference analysis might be making too broad an assumption in regard to the slope of the regression lines this investigator checked to see if any of the slopes were significantly different from 1. Comparison was made against a slope of 1 because it seems reasonable to expect that a student taking the post-test and pre-test at the same sitting would score the same on each. If this is not the case, then the tests are not equivalent measuring instruments. The mathematical model of this regression line is $y_i = \beta_o + x_i + e_i$ where y_i is the raw post-score and x_i is the raw pre-score. This line has a slope of 1 and is compared against $y_i = \beta_o + \beta_i x_i + e_i$ to find whether or not the slope of this line, β_i, is significantly different from 1.

The F-Ratio to test the slope of the regression line for each method and for each teacher against a slope of 1 is found by using the formula

$$F = \frac{R(\beta_1|\beta_o)}{1} \div \frac{\Sigma y_{11k}^2 - R(\beta_o,\beta_1)}{n_{11} - 2}$$

where $R(\beta_o,\beta_1) = \dfrac{(\Sigma y_{11k})^2}{n_{11}} + \dfrac{(\Sigma(y_{11k} - \bar{y}_{11\cdot})(x_{11k} - \bar{x}_{11\cdot}))^2}{\Sigma(x_{11k} - \bar{x}_{11\cdot})^2}$ and

$R(\beta_1|\beta_o) = R(\beta_o,\beta_1) - R(\beta_o)$ with $R(\beta_o) = \dfrac{(\Sigma(y_{11k} - x_{11k}))^2}{n_{11}}$.

The data for the required homework class of Teacher 1 is used to illustrate these computations.

$$R(\beta_o) = \frac{(\Sigma(y_{11k} - x_{11k}))^2}{n_{11}} = \frac{113^2}{28} = \frac{12769}{28} = 456.03.$$

$$R(\beta_o,\beta_1) = \frac{(\Sigma\, y_{11k})^2}{n_{11}} + \frac{(\Sigma(y_{11k} - \bar{y}_{11\bullet})(x_{11k} - \bar{x}_{11\bullet}))^2}{\Sigma(x_{11k} - \bar{x}_{11\bullet})^2} = \frac{(\Sigma\, y_{11k})^2}{n_{11}} + \frac{(\Sigma\, xy)^2}{\Sigma\, x^2}$$

$$= \frac{572^2}{28} + \frac{755.29^2}{952.68} = \frac{327184}{28} + \frac{570462.9841}{952.68}$$

$$= 11685.14 + 598.80 = 12283.94$$

$$R(\beta_1|\beta_o) = R(\beta_o,\beta_1) - R(\beta_o) = 12283.94 - 456.03 = 11827.91$$

$$\frac{\Sigma\, y_{11k}^2 - R(\beta_o,\beta_1)}{n_{11} - 2} = \frac{12714 - 12283.94}{28 - 2} = \frac{430.06}{26} = 16.54.$$

$$\text{Hence, } F = \frac{R(\beta_1|\beta_o)}{1} \div \frac{\Sigma\, y_{11k}^2 - R(\beta_o,\beta_1)}{n_{11} - 2} = \frac{11827.91}{1} \div 16.54 = 715.11.$$

A similar computation was made for each of the methods for all nine teachers. The F-Ratio values found are shown in Table VIII, page 44. One notes that in each instance the slope of the regression line is significantly different from 1 with a significance level of more than 99.5 per cent.

After finding all slopes to be significantly different from 1, this investigator used analysis of covariance to determine whether or not the two slopes for each teacher were significantly different. The same slope in both methods would indicate that the teacher had the same effectiveness for all students in the class regardless of method. This does not say that his effectiveness was the same using each method. Even though the slopes of the lines are not significantly different one line may be several (post-score) units above the other which would indicate greater effectiveness by one method than the other.

TABLE VIII

DEGREES OF FREEDOM AND F-RATIO VALUES TO DETERMINE IF SLOPE OF EACH REGRESSION LINE IS ONE

Teacher	Method	
	Required	Not Required
T_1	(1,26) 715.11^{xx}	(1,21) 707.79^{xx}
T_2	(1,15) 192.95^{xx}	(1,5) 157.07^{xx}
T_3	(1,19) 507.90^{xx}	(1,8) 2128.63^{xx}
T_4	(1,25) 566.59^{xx}	(1,20) 329.44^{xx}
T_5	(1,36) 944.84^{xx}	(1,22) 430.84^{xx}
T_6	(1,27) 1223.56^{xx}	(1,19) 238.15^{xx}
T_7	(1,40) 1108.94^{xx}	(1,41) 1231.09^{xx}
T_8	(1,25) 521.73^{xx}	(1,19) 268.39^{xx}
T_9	(1,10) 318.28^{xx}	(1,18) 774.99^{xx}

^{xx}Significant at .01 level of confidence.

Table IX, page 45 is the analysis of covariance to determine whether or not the two regression lines for Teacher 1 are parallel.

With 1 and 47 degrees of freedom an F-Ratio of 1.14 is not statistically significant and therefore the regression lines for Teacher 1 are considered parallel. Figure 1 shows the plotted data for Teacher 1 with the three regression lines. Although the lines for homework and non-homework do not have exactly the same slope, the slopes did not prove to be statistically different.

TABLE IX

ANALYSIS OF COVARIANCE FOR POST-TEST SCORE Y AND PRE-TEST SCORE X FOR STUDENTS OF TEACHER 1

Source of Variation	Sum of Products			Y adjusted for X			
	df	x,x	x,y	y,y	df	SS	MS	F
Required	27	952.68	755.29	1028.86	26	430.07		
Not Required	22	538.61	304.26	481.83	21	309.95		
Total	49	1491.29	1059.55	1510.69	48	757.89		
					47	740.01	15.74	
				Difference	1	17.88	17.88	1.14

The results of analyses of covariance for all nine teachers are shown in Table X. Three slopes are also shown for each teacher, one for the data on the homework class, one for the data on the non-homework class, and one for the combined group.

Table X, page 47, shows that in all but two cases the regression lines when homework was used and when it was not used were parallel if we accept a .10 confidence level. As stated earlier, this suggests that these teachers had the same effect on all students in the class whether they did or did not require homework. Even though these two ratios are not highly significant, the subsequent analysis is based on the assumption that the slopes of these lines are different. The slopes in all but two instances are less than 1 which indicates a greater gain for the students with low scores than that for students with high scores. The two exceptions are the non-homework classes for teacher 8 and teacher 9. In these cases, where the slope is greater than 1, there was a

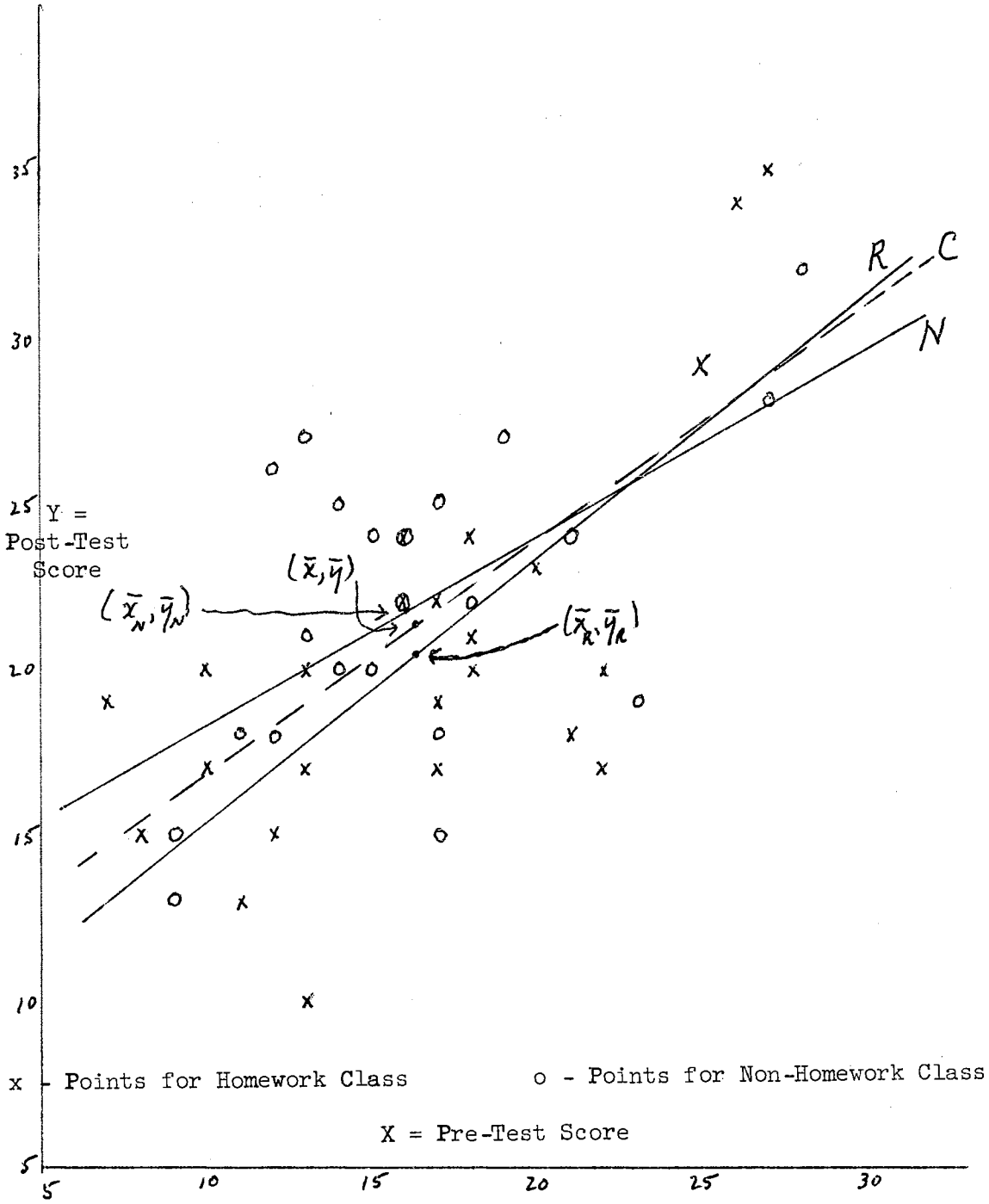

Figure 1

Plotted Data and Regression Lines for Teacher 1

TABLE X

SLOPES OF REGRESSION LINES, F-RATIOS, SIGNIFICANCE LEVEL AND INDICATION OF PARALLELISM FOR ALL TEACHERS

Teacher	Slopes			F	Significance Level	Parallel
	Required	Not Required	Combined			
1	0.793	0.565	0.710	1.140	.82	yes
2	0.474	0.815	0.511	0.570	.70	yes
3	0.853	0.249	0.761	1.067	.82	yes
4	0.725	0.578	0.666	0.715	.80	yes
5	0.946	0.538	0.819	3.900[1]	.95	no
6	0.839	0.532	0.773	1.560	.85	yes
7	0.663	0.720	0.696	0.127	.01	yes
8	0.434	1.057	0.693	3.458[1]	.925	no
9	0.659	1.016	0.815	1.314	.84	yes

[1]Significant at .10 level of confidence.

greater gain in achievement by the students with higher pre-test scores.

However, evidence supports the hypothesis that the lines for teacher 5 and the lines for teacher 8 were not parallel. For teacher 5 the F-Ratio of 3.90 with 1 and 58 degrees of freedom gives a significance level of 95 per cent. The significance level of the test of equality of slopes associated with teacher 8 was 90 per cent as a result of an F-Ratio of 3.065 with 1 and 45 degrees of freedom.

When one recognizes that observed variation in the dependent variable Y is partly attributable to variation in the independent variable X, covariance may be used as a method of controlling error. This

implies that the post-score means should be adjusted to make them estimates of what they would have been if all pre-score means had been the same. Consider the graph of two methods as shown in Figure 2.

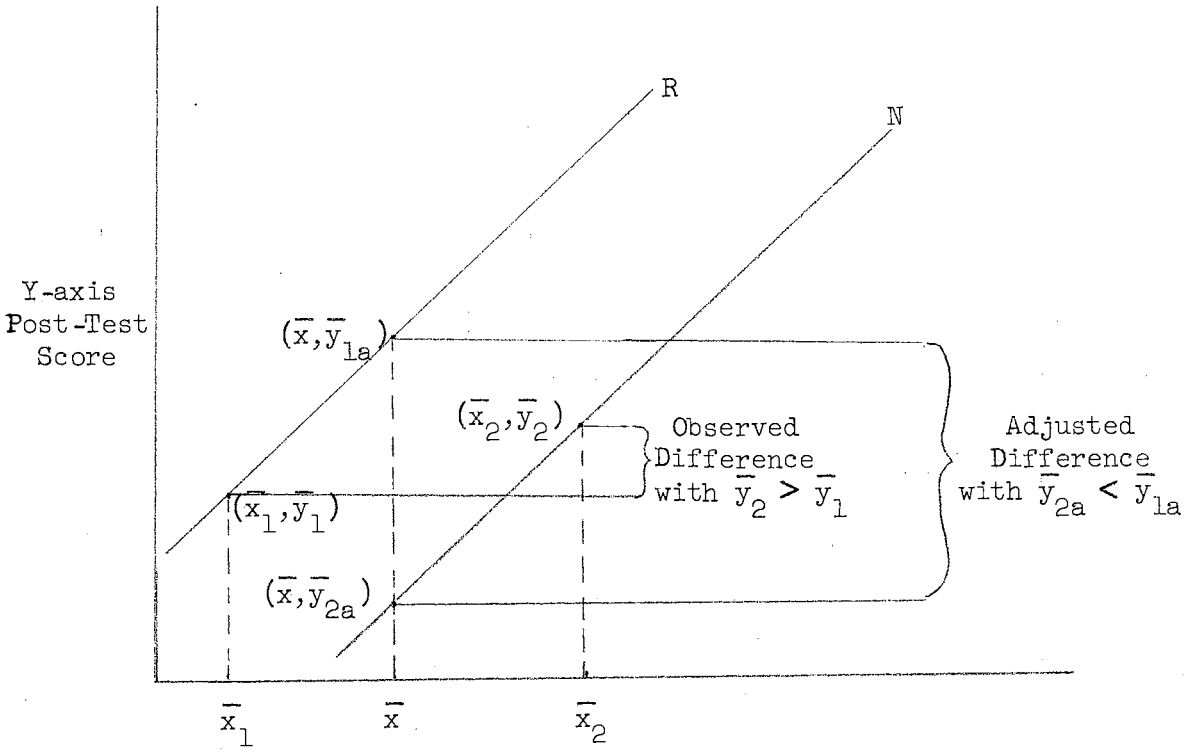

Figure 2

Error Control and Adjustment of Method Means by Covariance

For each method a change in the pre-test score is seen to contribute to the corresponding change in the post-test score. This suggests that differences in the post-test scores should be adjusted on the basis of the pre-test score. Also, reduction of the error variance is effected by use of pre-test score as covariate. When the post-score means are observed from the common pre-score, they are comparable. Thus, the need for adjusting means is indicated. In Figure 2 the adjusted post-

score means are labeled $\bar{y}_{1a}$ and $\bar{y}_{2a}$.

Covariance may be used to adjust method means of the dependent variable for differences in the independent variable. In the present research, the means for the data in which the regression lines were parallel were adjusted along the line with common slope to $\bar{x}$ = average of the means for the two methods. In the two cases where the lines were not parallel the adjustment was to $\bar{x} = (n_R\bar{x}_R + n_N\bar{x}_N) \div (n_R + n_N)$, but in each instance it was along the particular regression line. Actually, it is the difference in the adjusted post-score means which is of interest and this difference can be found for the parallel lines without evaluating the adjusted post-score means. The adjustment equations are $\bar{y}_R\ (adj) = \bar{y}_R - b_c(\bar{x}_R - \bar{x})$ and $\bar{y}_N\ (adj) = \bar{y}_N - b_c(\bar{x}_N - \bar{x})$ where b_c is the common slope. Hence, $\bar{y}_R\ (adj) - \bar{y}_N\ (adj) = \bar{y}_R - b_c(\bar{x}_R - \bar{x}) - \bar{y}_N + b_c(\bar{x}_N - \bar{x}) = \bar{y}_R - \bar{y}_N - b_c(\bar{x}_R - \bar{x}_N)$. In the two non-parallel cases it is necessary to find the adjusted post-score means. This information is shown in Table XI, page 50.

Now that the adjusted means have been obtained it seems reasonable to test these adjusted means. The general procedure in this case requires all three sums of products for method, i.e. Σx^2, Σxy, Σy^2, and for remainder after adjustment for all other sources of variation included in the model. From the method and remainder lines, a line for method plus remainder is obtained by addition. Σy^2 due to remainder and Σy^2 due to methods plus remainder are adjusted by subtracting the part due to linear regression. The difference between these adjusted sums of squares is the sum of squares used in testing adjusted method means.

TABLE XI

MEANS, DIFFERENCES IN UNADJUSTED MEANS AND

DIFFERENCES IN ADJUSTED MEANS

Teacher	$\bar{x}_R$	$\bar{y}_R$	$\bar{x}_N$	$\bar{x}_R - \bar{x}_N$	$\bar{y}_N$	Unadjusted $\bar{y}_R - \bar{y}_N$	Adjusted $\bar{y}_R - \bar{y}_N$
1	16.39	20.43	16.13	0.26	21.91	-1.48	-1.66
2	20.47	27.53	16.14	4.33	25.14	2.39	0.18
3	18.43	25.24	26.50	-8.07	33.40	-8.16	-2.02
4	17.11	24.22	19.00	-1.89	25.41	-1.19	0.07
5[x]	19.21	23.71	15.92	3.29	17.58	6.13	3.84[x]
6	19.48	22.90	18.81	0.67	21.76	1.14	0.62
7	19.12	27.36	20.53	-1.41	26.37	0.99	1.97
8[xx]	17.18	24.41	11.62	5.56	23.90	0.51	-3.85[xx]
9	10.08	26.00	22.15	-4.07	27.45	-1.45	1.87

[x](1) $\bar{y}_R\ (adj) = \bar{y}_R - b_R(\bar{x}_R - \bar{x}) = 23.71 - .946(19.21 - 17.94) = 22.51$

(2) $\bar{y}_N\ (adj) = \bar{y}_N - b_N(\bar{x}_N - \bar{x}) = 17.58 - .538(15.92 - 17.94) = 18.67$

$$\bar{y}_R\ (adj) - \bar{y}_N\ (adj) = 22.51 - 18.67 = 3.84$$

[xx](1) $\bar{y}_R\ (adj) = \bar{y}_R - b_R(\bar{x}_R - \bar{x}) = 24.41 - .434(17.18 - 14.75) = 23.36$

(2) $\bar{y}_N\ (adj) = \bar{y}_N - b_N(\bar{x}_N - \bar{x}) = 23.90 - 1.057(11.62 - 14.75) = 27.21$

$$\bar{y}_R\ (adj) - \bar{y}_N\ (adj) = 23.36 - 27.21 = -3.85$$

Table XII gives the analysis of covariance for testing the adjusted method means for Teacher 1.

TABLE XII

TESTING ADJUSTED METHOD MEANS

Source	df	Sums of Products of y,y	x,y	x,x	df	Adjusted Σy^2	MS	F
Total	50	1538.51	1054.63	1492.16				
Methods	1	27.83	-4.92	0.87				
Remainder	49	1510.69	1059.55	1491.29	48	757.89	15.79	
Methods + Remainder	50	1538.51	1054.63	1492.16	49	793.12		
-------				Difference	1	35.23	35.23	2.231

A similar analysis of covariance was completed for each teacher and the results are given in Table XIII, page 52.

The significance levels given in Table XIII, page 52, indicate the variety of differences that exist among the adjusted method means. The significance varies from 0 for two teachers to 100 for one teacher. For all but three teachers the significance level is above 82.5 per cent.

An overall test of the adjusted interaction means is the final test in this investigation. This analysis of covariance required use of Abbreviated Doolittle Technique to find the three sum of products for methods. The procedure was basically equivalent to that used in the analysis of variance for the complete set of data. The two analyses of covariance associated in this overall test are shown in Tables XIV, page 53, and Table XV, page 53. Only the pertinent part is shown in Table XV

rather than repeat all of Table XIV.

TABLE XIII

F-RATIOS WITH DEGREES OF FREEDOM AND

SIGNIFICANCE LEVEL FOR ADJUSTED METHOD MEANS

Teacher	F-Ratio		Significance Level
1	(1,48)	2.231	87.5
2	(1,21)	0.006	0
3	(1,28)	13.536[xx]	100
4	(1,46)	0.002	0
5	(1,59)	7.304[xx]	99
6	(1,47)	0.018	2.5
7	(1,82)	3.265	92.5
8	(1,45)	3.065	91
9	(1,29)	1.084	82.5

[xx]Significant at .01 level of confidence.

In Table XIV the F-Ratio is 2.735 with 8 and 413 degrees of freedom. The significance level for this is 99.5 per cent. Thus, we have evidence at the .01 confidence level that the teacher by method interaction is significant. This means that the difference in the two methods was not consistently in the same direction for all teachers when adjusted for average pre-score.

TABLE XIV

OVERALL TEST OF ADJUSTED INTERACTION MEANS

Source	df	Sums of Products of y,y	x,y	x,x	df	$\Sigma d^2_{y \cdot x}$	MS
Total	431	21472.66	13355.72	18461.72			
Teachers	8	2571.87	1205.31	1488.77			
Methods	1	18.08	0.78	11.34			
Teach. x Meth.	8	1113.60	872.82	1264.69			
Within	414	17769.11	11276.81	15696.92	413	9667.75	23.409
Teach. x Meth. + Within	422	18882.71	12149.63	16961.61	421	10179.91	
				Difference	8	512.16	64.020

TABLE XV

AUXILIARY TABLE FOR TESTING ADJUSTED METHOD MEANS

Source	df	y,y	x,y	x,x	df	$\Sigma d^2_{y \cdot x}$	MS
Methods	1	18.08	0.78	11.34			
Teach. x Meth.	8	1113.60	872.82	1264.69	7	511.23	
Teach. x Meth. + Methods	9	1131.68	873.60	1276.03	8	533.59	66.67
				Difference	1	22.36	22.36

The F-Ratio of 0.335 with 1 and 8 degrees of freedom from Table XV is significant at the 9 per cent level. Hence, when adjusted for average pre-score, the difference in achievement between the two methods is

not significant at either the .01 or .05 level of confidence.

Variances

Each of the analyses reported in this work is based on the assumption that the variances are the same in each class for each teacher. The variances which were found are given in Table XVI.

TABLE XVI

VARIANCES

Teacher	Pre-Test Score	Post-Test Score	Differences	Residual (Covariance)
1	30.43	30.83	20.06	15.79
2	59.60	39.60	38.31	25.19
3	22.75	32.15	16.82	19.66
4	29.46	36.30	26.51	23.73
5	38.44	47.56	23.05	22.16
6	50.68	55.05	27.33	25.26
7	49.39	48.60	29.27	25.00
8	24.80	44.09	34.50	32.88
9	29.05	39.70	21.37	21.08

Consideration of Table XVI gives justification for the equal variance assumption. It points up the fact that the within class variability is not affected by teaching, that is, the same amount of variation is present at the termination of the instruction as in the beginning. Control of variance by the use of covariance is exhibited in that the residual variance in the covariance analysis (Column 4) is in

every case less than the post-test variability.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Review of the Study

This study was primarily an investigation to find experimental evidence at the college level which might help to determine if student achievement in a course in college algebra is influenced by required homework. The results provide information which may be used by interested parties in decisions relative to required homework.

The specific hypothesis to be tested was that there exists no significant difference in achievement between students in a College Algebra class with required homework and students in a College Algebra class without required homework. Each teacher taught two classes in college algebra. In one class the students were required to do homework while in the other class no homework was required. Algebraic achievement was measured by a nationally standardized achievement test.

The standard scores received on Form A and Form B of New Cooperative Mathematics Tests, Algebra II were used as the pre-and post-measure of achievement in algebra. The hypothesis was tested by using the analysis of variance technique on the differences of pre-test and post-test scores, by the Mann-Whitney U Test on the differences, and by a covariance analysis on the raw scores with the pre-test score as covariate.

Conclusions of the Study

On the basis of this research and subject to the specified limitations, the findings of the study seem to justify the following conclusions:

1. Variability within classes is not affected appreciably by teaching. The variability in post-test scores was approximately the same as the variability in pre-test scores with variability in post-test scores slightly more.
2. The results of the analyses of the data by the analysis of variance technique, the Mann-Whitney U Test and analysis of covariance were consistent in that the significance levels of the same tests in each of the these analyses were approximately the same.
3. The assumptions involved in the covariance analysis for the data seemed to be more realistic than the assumptions of the difference analysis. The analysis of differences depended on the assumption that the slope of the regression lines was 1 and did not depend on the teacher or the method while the covariance analysis allowed for the slopes to be different for each teacher and method.
4. The slopes of the regression lines were not 1, and in fact were less than 1, because of the scale of measurement used. That is, persons with low pre-test scores had more opportunity to achieve than those with high pre-test scores.
5. Since slopes were not significantly different for the two methods for most teachers, the effectiveness of the teacher on the students in a particular class is not affected by the

method.

6. On the basis of results of the comparison of the two methods in each teacher one method is to be preferred over the other in some cases. However, the method to be used depends upon the teacher. This was substantiated by the highly significant method by teacher interaction adjusted for differences in the average pre-test score.
7. Neither method can be recommended for all teachers on the basis of the tests of the differences of the two methods averaged over all teachers.
8. Achievement in college algebra could be influenced by sectioning based on the type of information included in this study. This means that, based on the results of a study of this type on a particular teacher, an administrator could section students according to their pre-score and suggest to the teacher whether or not to use homework in a certain section.

It is not known to what population of teachers these conclusions are relevant. However, the writer feels that the conclusions bear sufficient significance to merit consideration by any teacher who is interested in homework requirement.

Recommendations

The writer of the present study is of the opinion that discoveries were made in this research that are significant to all persons interested in the homework problem. However, additional research should be done to further determine the influence of required homework. The writer makes the following recommendations as the result of this study:

1. More studies should be conducted comparing the influence of required homework and voluntary homework at the elementary level, secondary level, and college level.
2. Research is needed by a team of researchers from different subject matter fields working together in a thorough study of the homework problem at the college level.
3. Experiments should be conducted which cover a longer time interval and a larger student sample.
4. Research is needed in the field of attitudes to determine the influence of the students' attitude toward required homework on their achievement.

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APPENDIX A

ALPHABETICAL LIST OF SCHOOLS COOPERATING IN THE STUDY

Drury College	Springfield, Missouri
East Central State College	Ada, Oklahoma
Phillips University	Enid, Oklahoma
Southwestern State College	Weatherford, Oklahoma
University of Tulsa	Tulsa, Oklahoma

APPENDIX B

STANDARD SCORES ON FORM A AND FORM B OF NEW COOPERATIVE MATHEMATICS TESTS, ALGEBRA II AND DIFFERENCES OF THE TWO SCORES

Teacher 1

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	27	35	8	28	32	4
2	26	34	8	27	28	1
3	25	29	4	23	19	-4
4	25	29	4	21	24	3
5	22	20	-2	19	27	8
6	22	17	-5	18	23	5
7	21	18	-3	17	18	1
8	21	24	3	17	15	-2
9	20	23	3	17	25	8
10	18	21	3	16	24	8
11	18	20	2	16	22	6
12	18	24	6	15	20	5
13	17	19	2	15	20	5
14	17	22	5	15	24	9
15	17	17	0	14	20	6
16	16	24	8	14	25	11
17	16	22	6	13	21	8
18	13	20	7	13	27	14
19	13	10	-3	12	26	14
20	13	17	4	12	18	6
21	12	15	3	11	18	7
22	11	13	2	9	15	6
23	10	20	10	9	13	4
24	10	20	10			
25	10	17	7			
26	8	15	7			
27	7	19	12			
28	6	8	2			

Teacher 2

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	36	39	3	25	28	3
2	32	26	-6	18	27	9
3	30	34	4	17	31	14
4	28	32	4	15	31	16
5	26	27	1	15	22	7
6	26	34	8	14	23	9
7	25	34	9	9	14	5
8	21	25	4			
9	18	18	0			
10	18	35	17			
11	17	26	9			
12	17	25	8			
13	16	25	9			
14	14	18	4			
15	9	18	9			
16	8	23	15			
17	7	29	22			

Teacher 3

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	27	32	5	31	34	3
2	25	29	4	30	36	6
3	25	35	10	28	33	5
4	24	18	-6	27	33	6
5	22	31	9	27	35	8
6	22	26	4	27	33	6
7	22	27	5	27	36	9
8	21	33	12	25	28	3
9	21	26	5	24	33	9
10	21	28	7	19	33	14
11	18	23	5			
12	18	31	13			
13	18	32	14			
14	18	31	13			
15	15	20	5			
16	15	21	6			
17	13	18	5			
18	12	10	-2			
19	11	24	13			
20	10	19	9			
21	9	16	7			

Teacher 4

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	28	36	8	27	27	0
2	27	38	11	27	35	8
3	24	30	6	27	30	3
4	24	32	8	25	33	8
5	22	19	-3	25	29	4
6	21	25	4	24	30	6
7	21	35	14	21	24	3
8	21	25	4	20	22	2
9	21	25	4	19	26	7
10	20	28	8	19	22	3
11	19	19	0	19	22	3
12	18	14	-4	18	31	13
13	17	21	4	18	20	2
14	17	25	8	17	30	13
15	17	24	7	17	23	6
16	16	28	12	17	18	1
17	15	26	11	16	30	14
18	15	15	0	15	21	6
19	15	16	1	13	15	2
20	14	24	10	13	27	14
21	13	26	13	12	17	5
22	12	18	6	9	27	18
23	11	22	11			
24	11	29	18			
25	10	21	11			
26	8	17	9			
27	5	16	11			

Teacher 5

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	32	34	2	30	26	-4
2	32	33	1	26	31	5
3	29	34	5	24	25	1
4	28	29	1	21	12	-9
5	28	34	6	21	15	-6
6	26	28	2	18	17	-1
7	26	34	8	18	22	4
8	26	21	-5	18	16	-2
9	26	35	9	17	17	0
10	24	29	5	17	18	1
11	24	36	12	16	16	0
12	24	28	4	16	17	1
13	23	16	-7	16	16	0
14	23	34	11	15	18	3
15	23	30	7	13	9	-4
16	22	27	5	13	15	2
17	21	24	3	13	17	4
18	19	25	6	12	16	4
19	18	25	7	11	18	7
20	17	24	7	11	20	9
21	17	21	4	10	18	8
22	17	28	11	10	22	12
23	15	15	0	8	13	5
24	15	21	6	8	8	0
25	15	16	1			
26	14	21	7			
27	14	19	5			
28	13	18	5			
29	13	13	0			
30	13	26	13			
31	13	22	9			
32	12	17	5			
33	12	13	1			
34	12	5	-7			
35	11	15	4			
36	11	22	11			
37	11	10	-1			
38	11	19	8			

Teacher 6

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	37	37	0	32	37	5
2	35	38	3	25	22	-3
3	35	31	-4	25	24	-1
4	30	32	2	24	16	-8
5	28	33	5	22	17	-5
6	27	31	4	21	28	7
7	26	22	-4	21	19	-2
8	25	27	2	20	27	7
9	24	32	8	19	14	-5
10	24	22	-2	19	24	5
11	22	21	-1	19	19	0
12	20	24	4	17	22	5
13	20	24	4	17	34	17
14	19	24	5	17	28	11
15	17	23	6	17	12	-5
16	16	22	6	17	20	3
17	16	23	7	15	26	11
18	15	25	10	13	12	-1
19	15	24	9	13	23	10
20	14	17	3	12	12	0
21	13	19	6	10	21	11
22	13	15	2			
23	12	21	9			
24	12	12	0			
25	12	20	8			
26	11	15	4			
27	11	14	3			
28	9	11	2			
29	7	5	-2			

Teacher 7

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	37	37	0	38	39	1
2	31	36	5	36	35	-1
3	29	32	3	32	35	3
4	28	34	6	30	35	5
5	26	26	0	29	32	3
6	26	36	10	28	37	9
7	25	32	7	27	26	-1
8	25	35	10	27	31	4
9	25	27	2	27	31	4
10	24	29	5	27	30	3
11	24	32	8	26	36	10
12	23	22	-1	26	35	9
13	22	34	12	26	23	-3
14	22	27	5	25	25	0
15	22	25	3	24	30	6
16	22	31	9	23	33	10
17	21	33	12	22	28	6
18	21	27	6	22	28	6
19	20	31	11	22	31	9
20	20	33	13	22	25	3
21	20	35	15	21	25	4
22	19	35	16	21	25	4
23	18	20	2	20	31	11
24	18	28	10	20	26	6
25	17	34	17	19	21	2
26	17	31	14	18	16	-2
27	16	27	11	18	23	5
28	15	33	18	17	24	7
29	15	22	7	17	34	17
30	15	20	5	17	20	3
31	14	27	13	16	19	3
32	14	15	1	16	32	16
33	14	21	7	16	24	8
34	14	11	-3	15	18	3
35	13	16	3	14	27	13
36	13	19	6	13	24	11
37	12	21	9	13	15	2
38	11	32	21	11	16	5
39	11	23	12	10	17	7
40	10	20	10	10	16	6
41	7	20	13	10	16	6
42	7	20	13	7	32	25
43				5	8	3

Teacher 8

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	27	29	2	27	33	6
2	25	25	0	17	34	17
3	24	26	2	16	23	7
4	23	34	11	15	26	11
5	23	26	3	15	25	10
6	23	31	8	13	33	20
7	23	29	6	13	25	12
8	21	31	10	12	33	21
9	21	14	-7	11	27	16
10	18	28	10	11	17	6
11	18	21	3	11	27	16
12	18	23	5	10	19	9
13	16	20	4	10	33	23
14	16	29	13	10	22	12
15	16	21	5	10	24	14
16	16	21	5	10	28	18
17	15	35	20	10	25	15
18	14	26	12	8	15	7
19	13	18	5	6	17	11
20	13	25	12	5	6	1
21	13	19	6	4	10	6
22	13	15	2			
23	13	26	13			
24	12	24	12			
25	11	21	10			
26	11	14	3			
27	8	28	20			

Teacher 9

	Required Homework			Not Required Homework		
Student	Form A	Form B	Difference	Form A	Form B	Difference
1	28	28	0	31	39	8
2	27	29	2	29	35	6
3	25	29	4	27	29	2
4	22	34	12	27	30	3
5	21	31	10	25	36	11
6	19	25	6	25	34	9
7	18	33	15	25	31	6
8	14	26	12	24	22	-2
9	12	16	4	23	30	7
10	12	28	16	23	26	3
11	10	15	5	22	27	5
12	9	18	9	20	19	-1
13				19	30	11
14				19	24	5
15				19	31	12
16				19	16	-3
17				18	28	10
18				17	20	3
19				17	22	5
20				14	20	6

VITA

LYSLE C. MASON

Candidate for the Degree of

Doctor of Education

Thesis: A STUDY OF THE INFLUENCE OF COMPULSORY HOMESTUDY ON THE ACHIEVEMENT OF COLLEGE STUDENTS IN COLLEGE ALGEBRA

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Biographical:

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Education: Attended elementary school in Altoona, Benedict, Mont Ida, Yates Center, and Westphalia, Kansas; graduated from Elk City High School, Elk City, Kansas in 1935; attended Coffeyville Junior College, Coffeyville, Kansas, 1935-1936; received the Bachelor of Science in Education degree from Pittsburg State College, Pittsburg, Kansas with a major in mathematics in June, 1938; received the Master of Science degree from the University of Michigan, with a major in mathematics, in August, 1942; completed requirements for the Doctor of Education degree at Oklahoma State University, Stillwater, Oklahoma, May, 1965.

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