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EFFECTS OF RELEVANCY OF CONTENT ON ATTITUDES TOWARD, AND ACHIEVEMENT IN, MATHEMATICS BY PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for The Degree Doctor of Philosophy in The Graduate School of The Ohio State University

By

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1969

Approved by

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CHAPTER I

THE PROBLEM

In the past decade several significant reports have been issued which put forth recommendations for the mathematical preparation of elementary school teachers. The reports of The Commission on Mathematics (3, 49)\(^1\) in 1959, The Committee on the Undergraduate Program In Mathematics (4) in 1961, Conant (5, 154-160), The National Association of State Directors of Teacher Education and Certification (18) in 1963 and The Cambridge Conference on Teacher Training (9) in 1966 contained what might be called "upgrading-of-content" recommendations. Because the recommended content was in some instances difficult, the question arose as to how the instruction should be conducted. Young (55, 88) pointed to this in 1968 when he stated

> Not only should the number of mathematics credits be increased but the quality of these courses must be strengthened. The material is difficult and must be taught by a teacher who really understands it. Too often, the student is taught either by a doctoral student who demands too much

\(^1\)This notation is used to indicate bibliography item 3, p. 49.
rigor or by a perfectly fine teacher of eleventh grade algebra who knows little about new mathematics.

But how is the quality of these courses to be improved? A partial answer to this problem might be provided by improving the methodology in the teaching of mathematics to prospective elementary teachers. Specifically, if the instruction relates the content to be learned to the future classroom needs of the prospective teacher will significant growth in attitude and achievement result? The aspect of relevancy of content to future classroom needs is of fundamental concern in this study.

NEED FOR THE STUDY

The need for the improved mathematical preparation of prospective elementary school teachers has been the subject of numerous studies and reports. Grossnickle (36) and Newson (47) in 1951 and Ruddell et al. (51) in 1960 made recommendations for improving the mathematical content of teacher education before the so-called modern mathematics era. However, very little change in the mathematical preparation of prospective elementary school teachers took place until after the new mathematics began to be widely taught in the elementary schools throughout the United States (53, 137).
Then the need of elementary school teachers for additional mathematical knowledge became readily apparent.

In 1961, the teacher-training panel of The Committee on the Undergraduate Program in Mathematics (CUPM) of the Mathematical Association of America published a report (4) which defined a minimal competency level for teachers of elementary school mathematics. The recommendations of this report provided for twelve semester hours of college mathematics and are described concisely in the following quotation from the 1961 CUPM report entitled, Recommendations for the Training of Teachers of Mathematics (4, 11).

As a prerequisite for the college training of elementary school teachers, we recommend at least two years of college preparatory mathematics consisting of a year of algebra and a year of geometry, or the same material in integrated geometry, or the same material in integrated courses. It must also be assured that these teachers are competent in the basic techniques of arithmetic. The exact length of the training program will depend on the strength of their preparation. For their college training we recommend the equivalent of the following courses:

(A) A two-course sequence devoted to the structure of the real number system and its subsystems.

(B) A course devoted to the basic concepts of algebra.

(C) A course in informal geometry.

The material in these courses might in a sense duplicate material studied in high school by the prospective teacher, but we urge that this material be covered again, this time from a more sophisticated college level point of view.
College courses patterned after these recommendations and books to be used in these courses quickly came into existence. In addition, during the years between 1962 and 1966 an extensive series of conferences was held throughout the United States by the Teacher Training Panel of CUPM. Gail S. Young, Chairman of The CUPM Teacher Training Panel (1964), in 1968 described these conferences and the subsequent work of CUPM (55, 88).

The format was fairly standard. At the two-day meeting, a local speaker described how terrible the situation was in the state, and an outside speaker explained why the new proposal was good. Audiences were excited by the prospects, but progress has been slow.

At the present time, seven years after the final proposals were made, only seven schools offer the entire CUPM program. Much work is yet to be done. However, during the four years of concentrated effort to upgrade mathematics education, the median numbers of semester hours of mathematics to be completed by elementary majors doubled from three to six. Many schools now require nine.

Not all individuals who reviewed the CUPM recommendations in detail agreed that those recommendations were indeed the answer to the needs of prospective elementary teachers. R. Davis (6, 61) pointed out that

Many feel that the kind of mathematical directions indicated by the Nuffield Project comes closer to what young children -- and the teachers of young children -- really need than the CUPM recommendations do.
Although courses and texts have been prepared and conferences organized in response to the teachers' recognized need, these activities have not been completely successful in providing elementary school teachers with the mathematical knowledge needed to teach the many current elementary school mathematics programs. Mayor (43, 349) reported in 1966 after polling 22 leaders in mathematics education in all parts of the country, including college and university mathematicians, state department of education personnel and supervisors and teachers at elementary and secondary levels, that the most urgent need in mathematics education was an improved program of pre-service and in-service education in mathematics for elementary school teachers. It was frequently emphasized that the deficiencies were the fault of colleges and universities and school administrations -- not the over-worked classroom teacher.

Mayor (43, 350) went on to say that, while CUPM had achieved a high degree of success in bringing about an awareness of the shortcomings in the mathematics education for elementary school teachers and in recommending a considerable improvement in offerings for elementary school teachers, "we need some exciting new approaches in teaching teachers how to learn
The solution to the problem of preparing prospective elementary teachers to teach elementary school mathematics adequately is much less certain today than it seemed a decade or so ago. Mueller (46, 65) in emphasizing this dilemma, wrote that

1. The numbers course proposed by CUPM had made a significant penetration into the preservice work of prospective elementary teachers, but not the recommended algebra and geometry courses (33, 194-97).

2. Between 1962 and 1966, while most colleges increased the number of hours required of elementary education students, 58 of 715 colleges surveyed by CUPM actually reduced the number of required hours of mathematics (26, 198-99).

3. When 218 elementary school teachers, recent graduates of a major state university, were questioned about their less-than-CUPM preservice preparation, 78 percent expressed a desire for further courses; but by about a two to one majority they expressed preference for methods courses over content courses (49, 190-93).

4. In five Texas school districts, 1,075 teachers who had taken part in one or more in-service programs designed to prepare them to teach new mathematics were given a 120-item test and were handily outscored 65 to 56 by a control group of 124 sixth graders (27, 205-8).

Goodlad (11, 110), concerned with the continuing self-renewal of the current curriculum reform movement, wrote that

Prospective teachers also will have to be trained in the processes and concepts that they in turn have to develop in their students. Teachers and teachers of teachers alike must get their hands dirty and their minds involved in the "stuff" of learning.
In 1966, the Cambridge Conference on Teacher Training (CCTT) met to consider the educational needs of teachers who would be teaching content such as that outlined in *Goals for School Mathematics* (10), a report in which a wide range of new topics was suggested for inclusion in the elementary school. In 1967, CCTT issued its recommendations in *Goals for Mathematical Education of Elementary School Teachers* (9).

The 1966 Conference did not consider its proposals to be in conflict with the CUPM recommendations which it regarded as positive and immediately applicable. Four members of the CUPM Teacher Training Panel participated in the 1966 Conference. There was considerable overlap between the material in the CUPM recommendations and the CCTT proposals, although the latter went considerably beyond and involved more recommended mathematical content than the former. The CCTT recommendations were directed at a time when the CUPM recommendations will have been implemented and the new generation of prospective teachers, coming into college from improved courses in high school, will have profited by that implementation (9, 15).

Although the mathematical course content recommended by CUPM has been upgraded by the CCTT, there appears to be growing in the field of mathematics...
education a concern for the manner in which the mathematical content is taught to the prospective teacher. The development in elementary teachers of an adequate understanding of the mathematics needed to teach the content of The Goals Report was viewed in the 1966 teacher-training conference as the most important task that could be accomplished (9, 97). Morley (45, 59) in criticizing the CCTT Report, challenged the underlying assumptions of CCTT.

I am not here arguing against the need for teachers to know and understand more mathematics, but about the tactics of the college approach. The CCTT puts too much faith in what can be done by improved "content" courses in isolation.

Morley (45, 59) went on to say that

Those who fear mathematics and have shown little ability in it often find a renewal of confidence and interest through work on limited topics with a small group of children. For these reasons, in my experience, to completely dissociate discussion of aspects of teaching mathematics and, virtually, work with children, from teaching the mathematical content is to invite trouble because it cuts these students off from their own source of motivation. However good the mathematics course may be it seems irrelevant and they switch it off.

Spitzer (53, 137), in 1969, pointed out that the inadequacy of current college mathematics courses for prospective elementary teachers is frequently mentioned by teachers of mathematics methods courses, by supervisors, and by the teachers who have taken the
courses. This dissatisfaction with the mathematics courses for prospective elementary teachers is a problem which warrants careful consideration.

It seems to me that a major reason for students' dissatisfaction is their failure to see much relationship between what they study in these courses and their image of what mathematics they will teach to children in the elementary school (53, 138).

Spitzer (53, 138) went on to pinpoint the source of teacher dissatisfaction.

Because the content for these mathematics courses was selected for its relevance to the K-6 elementary school mathematics program, it would seem that this criticism could hardly be valid. Yet it exists. Reasons for this are probably varied, but chief among them is the manner in which content is presented -- either by the college textbook or by the college instructor or by both.

Young (55, 88) appeared to recognize the inadequacies cited by Spitzer when he said that the material recommended by CUPM is difficult and must be taught by a teacher who really understands it. "This happens all too rarely." Young (55, 89) mentioned that, although the courses recommended by CUPM should be enjoyable courses with the prospective teacher learning something and attaining a positive attitude toward mathematics, several textbooks have been written which follow the CUPM recommendations so closely that, "The letter killeth."
What are noticeably missing from the literature are recommendations as to how the mathematics content courses should be taught. Lomon (40, 98) pointed out that the discovery approach should be part of the teaching technique used with prospective teachers. The 1966 Conference advocated a correlation between the methods and content courses in college. But Lomon (40, 98) said that this did not go far enough: "This relation must be more than that the two types of courses talk about each other." Spitzer (53, 139) in 1969, wrote that the time had arrived when elementary school-teachers-to-be should expect that the required college mathematics classes, and the materials of instruction used in those classes, reflect the kind of a mathematics program that was envisioned for the elementary schools where those students were to teach.

During the winter and spring quarters of 1968, the experimenter in this study was an assistant to the instructor for Principles of Mathematics, a mathematics content course required for prospective elementary school teachers at The Ohio State University and commonly referred to as "Mathematics 105". The experimenter attended the weekly lectures and listened attentively to the presentations. As he listened to the lectures, he realized that much of the content being
taught could be found in current elementary mathematics textbook series. The question arose as to whether or not the course could be improved by more closely relating the mathematics being presented to the future needs of the elementary school teacher. The informal questioning of several Mathematics 105 students provided evidence that a large segment of the course participants saw no need or relevancy of the course to their future needs. Several students appeared to have poor attitudes towards learning in general, and mathematics in particular. Many students felt that Mathematics 105 was a requirement to be fulfilled for graduation, nothing more.

The experiment to be described in this dissertation is an attempt to provide a partial answer to the question of how methodology in the teaching of mathematics to prospective elementary school teachers might be improved so that more positive attitudes toward, and greater achievement in, mathematics would result.

THE PROBLEM STATEMENT

Does the use of an in-context method of teaching mathematics produce significantly more positive attitudes toward, and significantly greater achievement in, mathematics among prospective elementary school
teachers than the use of the lecture method of teaching mathematics?

**Definition of Terms**

1. **In-context method of teaching** is defined to be a method of teaching in which the instructor relates the material being taught to the work of the elementary classroom. The primary method of presentation is the use of picture-slide reproductions of selected elementary mathematics textbook pages. The lecture method of teaching will be used whenever picture-slide reproductions are not available for the purpose of presenting the content.

2. **Lecture method of teaching** is defined to be that method of teaching in which the instructor uses primarily a one-way oral communication method to teach the daily lessons in mathematics. No slide reproductions are used to present the daily lessons nor does the instructor relate the daily material directly to the classroom needs of the prospective elementary school teacher. Rather, mathematics is learned for its own sake.

3. **Attitude** is defined to be the measure of the attitudes toward mathematics by the Mathematics 105 participants as measured by the Shatkin instrument.
The measure of student attitude will be the measure of the adjusted attitude posttest scores of the subjects. Students who have higher attitude posttest scores will be considered as having more positive attitudes than those students with lower scores. The attitude posttest scores will be adjusted by an analysis of covariance using attitudes and achievement pretest scores as covariates.

4. **Achievement** is defined to be the measure of achievement in mathematics by the Mathematics 105 participants as measured by an achievement test constructed by the experimenter (Appendix A). The measure of student achievement will be the measure of the adjusted achievement posttest scores of the subjects. The achievement posttest scores will be adjusted by an analysis of covariance using attitude and achievement pretest scores as covariates.

5. **Prospective elementary school teachers** are defined to be those students who are presently enrolled in the preservice elementary school teacher preparation program at The Ohio State University.

**OBJECTIVES OF THE STUDY**

An objective of this study was to determine by achievement testing whether or not the use of the
in-context method of teaching Mathematics 105 produced greater mathematical achievement in prospective elementary school teachers than did the use of the lecture method of teaching.

A second objective of this study was to determine by means of a standardized attitude test whether or not the use of the in-context method of teaching Mathematics 105 produced more positive attitudes toward mathematics in prospective elementary school teachers than did the use of the lecture method of teaching.

HYPOTHESES

The following set of hypotheses were tested in this study:

$H_0$: There is no significant difference between treatment $X$, the experimental treatment, and treatment $C$, the control treatment, with respect to mathematical achievement in the course being taught.

$H_1$: There is a significant difference between treatment $X$, the experimental treatment, and treatment $C$, the control treatment, with respect to mathematical achievement in the course being taught.
There is no significant difference between treatment X, the experimental treatment, and treatment C, the control treatment, with respect to attitude toward mathematics.

H₁: There is a significant difference between treatment X, the experimental treatment, and treatment C, the control treatment, with respect to attitude toward mathematics.

RELATED STUDIES

There has been a paucity of studies conducted in the area of improving instruction in mathematics for prospective elementary school teachers. Much of the research which has been conducted has dealt with the improvement of mathematics course content for prospective teachers, descriptive studies of prospective elementary teachers' academic backgrounds, the inadequacy of the pre-service mathematical preparation of teachers, and with methods of improving prospective teacher attitudes and understanding of mathematical concepts in methods-of-teaching-mathematics courses. This review of the literature will explore primarily studies related to the improvement of instruction in mathematics courses for prospective elementary school teachers because this study was concerned with attitude and
achievement as influenced by different teaching procedures in a mathematical content course. Research in the areas listed in the second sentence of the paragraph will be briefly described.

**Improvement of Instruction in Mathematics**

Fitzgerald (34) reported in 1968 a newly designed course in mathematics at Michigan State University in which the prospective elementary teachers experienced learning situations in mathematics which were individually-oriented and activity-centered. Students attended three lectures per week and a two-hour laboratory session which was limited to groups of thirty students. The laboratory sessions were material-centered. The objectives of the laboratory sessions were:

1. to learn the mathematical concepts of the course;

2. to become familiar with the materials and how they may be used; and,

3. to provide a real learning experience in mathematics in a student-centered rather than a teacher-centered classroom.

Fitzgerald (34, 548) wrote that Assessment of the effects of the laboratory
thus far seem to indicate that the mathematical competence of the students is unchanged. However, the subjective statements from the students reflecting their attitudes are highly positive regarding their laboratory experiences.

Wickes (74), in 1967 conducted a comparative study in which one group of prospective elementary school teachers was taught a combined mathematics content and methods-of-teaching-mathematics course. The control group was taught a mathematics content course followed by a methods-of-teaching-mathematics course. The effects on attitude and achievement of the two groups were then determined. Wickes reported that his evidence showed no significant difference in attitude between the two groups. His experiment did show a significant difference in achievement by the mathematics-and-then-methods group when compared with the combined mathematics and methods group.

In 1966, Bassler (56) reported that the use of different types of exercises in a mathematics course for prospective elementary school teachers had no significant influence on achievement. The exercises which were compared were those framed in a physical world setting versus those framed in a purely mathematical setting. Bassler concluded that the role of exercises in this kind of a course is not as great as believed.
Spitzer (53, 137-9) in criticizing the current methods of teaching mathematics to prospective teachers illustrated the teaching of a lesson in geometry to a college class of elementary education majors. The approach used in the presentation included a dialogue between a kindergarten teacher and her students while the students were playing a game to identify a geometric figure. To quote Spitzer (53, 139)

> It is my firm belief that the study of geometry, guided by such questions as those given in the preceding sections, proves to be no less fruitful than study guided by questions and suggestions based on material in current college textbooks. Such an approach to the study of geometry makes it easier for college students to recognize that college mathematics is indeed relevant to elementary school mathematics.

**Improvement of Mathematics Content**

Casebeer (58), Hankebo (63) and Hurd (66) each studied the effect on the understanding of mathematical concepts by prospective elementary teachers when new content was introduced. In particular, Casebeer used two different approaches to the teaching of positional numeration systems to prospective elementary teachers. He found no significant differences between the treatments in the basic understanding of basimal numeration systems or in the understanding of the conversion from
one base to another. On the basis of his experiment, Hankebo concluded that the study of nondecimal numeration systems did not enhance and reinforce the understanding of the decimal numeration system by prospective elementary teachers. Hurd taught a unit on finite mathematical systems to an experimental group. His experiment provided evidence that this content did not enhance the understanding of the concept "operation", of the properties of the real number system, or of the elementary ideas of proof.

Hurd has an extensive survey of the related content studies in the area of prospective elementary teacher training in mathematics (66, 6-31).

**Improvement of Attitude**

Todd (54) in 1966, reported a comprehensive review of the literature regarding teacher attitude towards mathematics. He pointed out that in 1947 Glennon constructed a test of basic concepts of arithmetic; his report of the lack of understanding by students and by teachers led to intensified efforts to improve the mathematical background of both pre- and in-service teachers (35). Dutton's development of attitude scales revealed that many potential teachers disliked arithmetic (30). Other studies reported that
negative attitudes toward arithmetic were formed as early as third grade (32). Lyda and Morse found that improving the attitudes of pupils also improved their achievement scores (42). Bassham, Murphy and Murphy found a relationship between attitude toward arithmetic and efficiency of learning (25).

In 1966, both Gee (60) and Gilbert (62) concluded from their research that positive attitudes were related to success in a mathematics content course. Gilbert reported that the objectives of a content course should be to develop a fuller understanding of arithmetic and to develop positive attitudes towards arithmetic.

In 1968, Kane (39) reported the results of a study conducted with 58 elementary education majors at the close of their student teaching period. His research showed that the attitudes of prospective elementary teachers toward mathematics were relatively high. Among prospective teachers in grades 4-6, mathematics enjoyed the highest attitudinal status when compared with the disciplines of English, science and social studies. Among grade K-3 prospective teachers, attitudes toward mathematics did not seem to be univocal. While mathematics, science and social studies evoked about the same number of first place selections
as to preference, mathematics received more last place selections. Kane (39, 174) also stated

It appears that prospective teachers who have relatively unfavorable attitudes toward mathematics tend to prefer teaching assignments in the primary grades, while those who have the most favorable attitudes toward mathematics tend to prefer assignment in the intermediate grades.

Reys and Delon (49) examined the attitudes of prospective elementary teachers in 1968. The focus of the study was on the overall mathematics preparation program for elementary education majors rather than on a particular course in the program. Sixty percent of the elementary education majors expressed a favorable attitude toward arithmetic. The mathematics course produced some positive change in the students' attitude toward arithmetic; however, the overall change in attitude from beginning to end of the preparatory program was not statistically significant.

Inskeep (38) on the basis of his research, stated in 1968 that content preparation of prospective elementary school teachers is a necessary, but not sufficient, condition for effective teaching of mathematics and, that there seems to be a relationship between the attitudes of students and their composite background and performance in class. The data from his study seemed to support this hypothesis.
Shatkin (72) reported in 1968 that his research showed evidence that attitude change in mathematics among prospective elementary teachers correlates significantly with achievement in an elementary mathematics course. Shatkin stated that attitude change towards mathematics among his students was a function of the students' success in the mathematics course which they were taking.

Inadequacy of Mathematics Preparation

Withnell (76), after examining 2513 prospective elementary teachers from large universities, large colleges and small colleges having 3, 6 or 9 semester hours preparation in mathematics, found that the understanding of mathematical concepts by these prospective teachers was low. Melson (44) pointed out in 1965 that two-thirds of 41 newly hired elementary school teachers she tested were not adequately trained in college to teach the elementary mathematics concepts which have been recommended for grades 1–6 by The National Council of Teachers of Mathematics, The New York State Department of Public Instruction and the authors of recently (1965) published mathematics texts and materials. Smith's study (52) seemed to repudiate Melson's contention that prospective elementary
teachers were not being adequately prepared in mathematics. Rouse's research (71) indicated a low negative correlation between pupil achievement, K-6, and teacher college mathematics preparation. Callahan's research (57) showed that the mathematical knowledge of prospective teachers declined from the freshman to the senior year of teacher preparation. William's study (75) showed that teachers and principals have insufficient preparation in mathematics and that preservice teacher education programs have neglected the mathematics preparation of prospective elementary school teachers. Studies by Creswell (59) and Strain (73) point to the poor achievement performance of prospective elementary teachers when compared with students who are not elementary education majors.

Studies of a somewhat different nature from those mentioned previously were reported by Reys and Moffitt. Reys (69) reported that seventy-nine percent of the recent graduates of a large university stated a need of additional preparation for teaching mathematics in the elementary school. Moffitt (67) reported that twenty percent of the prospective teachers, teachers and supervisors studied felt that general education should be more closely related to the elementary classroom.
This concludes the review of the literature. The remaining chapters of this dissertation will be concerned with a description of the study, an analysis and interpretation of the data, and conclusions, limitations and recommendations.
CHAPTER II

DESCRIPTION OF THE STUDY

The study to be described was conducted at The Ohio State University during the Winter Quarter, 1969. As mentioned in the previous chapter, the objectives of the study were two-fold:

1. to determine by achievement testing whether or not the use of the in-context method of teaching Mathematics 105 produced greater mathematical achievement in prospective elementary school teachers than did the use of the lecture method of teaching; and,

2. to determine by means of a standardized attitude test whether or not the use of the in-context method of teaching Mathematics 105 produced more positive attitudes toward mathematics in prospective elementary school teachers than did the use of the lecture method of teaching.

A description of the course, the subjects, the treatment and the design follows.
COURSE BACKGROUND AND DESCRIPTION

Students in elementary education at The Ohio State University are permitted to enter a program of elementary teacher education with relatively weak backgrounds in mathematics. All incoming freshmen in elementary education are tested in mathematics before the start of their first quarter at the university. The purpose of this testing is to determine the students' proficiency in mathematics. On the basis of the students' prior mathematics achievement, as measured by the American College Test, each student is required to take one of two mathematical placement examinations which is used to place the student at one of five levels. If a student places at Level Five, the lowest level, he must take a remedial algebra course which is the equivalent of a first year algebra course. This remedial course is offered by the Columbus Public Schools and carries no university credit. If a student places at Level Four, he must take Mathematics 101, a university course whose content is similar to that of a high school algebra two course. Students who place at Level Three or above are not required by The College of Education to take any mathematics other than Mathematics 105 whose description
will follow in a later section. The mathematics placement examination consists of forty questions, twenty-four of which are of the difficulty of eighth grade arithmetic and 6 of which are from geometry.\(^2\)

For the degree, Bachelor of Science in Education, elementary education majors are required to complete one five-quarter hour general education course in "Principles of Mathematics" which is commonly referred to as "Mathematics 105". While this course is designed for prospective elementary teachers, it is offered by the Department of Mathematics and is taught by instructors from this department. The course is offered in the winter, spring and summer quarters of each school year. Because Mathematics 105 is a prerequisite for Education 502, which is the elementary mathematics instructional methods course at The Ohio State University, Mathematics 105 is usually taken by prospective elementary teachers in their freshman or sophomore year.

An objective of Mathematics 105 is to develop the basic ideas of elementary mathematics through the study of patterns, sets, decimal and nondecimal

\(^2\)This information regarding the testing of incoming freshmen was obtained from an interview with Dr. Robert W. Ullman, Director - Orientation and Testing, The Ohio State University.
numeration systems, elementary number theory and the properties of the non-negative rational numbers. A more complete listing of the topics taught in Mathematics 105 during the winter quarter is found in Appendix D.

The basic text which was used is Ward and Hardgrove, Modern Elementary Mathematics, a text "written especially for teachers and administrators of elementary schools" (22, v). All but four of the twenty-three homework assignments came from this text. The four exceptions were specially prepared hand-outs which either emphasized in greater detail topics found in the basic text, e.g. numeration systems, or provided exercises for topics discussed in lecture but not found in the text, e.g. probability. The instructor for the course used Groza's A Survey of Mathematics (12), McFarland and Lewis' Introduction to Modern Mathematics (16), Peterson and Hashisaki's Theory of Arithmetic (19) and Willerding's Elementary Mathematics (23) as supplemental reference books to prepare his lecture notes.

COURSE MANAGEMENT

Two sections of Mathematics 105 were available winter and spring quarters because of the large course
enrollment. Each section was taught daily, one section having been taught at 12 p.m. and the other section having been taught at 2 p.m. Class periods were 48 minutes in length. On Monday, Wednesday and Friday there were large group lectures which were expository in nature and which were given by the same instructor, an instructor chosen by the Department of Mathematics for this course with consideration for his mathematical and professional qualifications.

On Tuesdays and Thursdays small group recitation meetings were conducted by assistants to the instructor. The size of the recitation groups and the number of assistants to the instructor was dependent upon the course enrollment. During the winter quarter, 1969, there were 430 students enrolled in Mathematics 105 which necessitated the use of seven assistants. The twelve o'clock recitation class size averaged approximately 33 students per section; the two o'clock class size averaged 29 students per section.

The assistants for the course were appointed by the Department of Mathematics. Their primary responsibility was to conduct the recitation meetings wherein the homework assignments were reviewed. Secondary responsibilities included the provision of out-of-class help to students and the administration and evaluation of the course examinations. There were
three 55-minute examinations and one 120-minute final examination. These examinations were common examinations, constructed by the lecture instructor and given at the same time to all the Mathematics 105 students. Student grades were determined by the lecture instructor.

It is important to note that those students who were taught at twelve o'clock went to twelve o'clock recitation sessions; those students who were taught at two o'clock went to two o'clock recitation sessions. Each assistant had a seating chart and a class role. There was no mixing of the twelve and two o'clock recitation groups. There was very little or no time for the introduction of new material in the recitation meetings because of the amount of material which had to be discussed and explained.

Finally, each assistant conducted two recitation sessions on Tuesday and again on Thursday. Because of this arrangement, each assistant conducted a session for a group of twelve o'clock students and a recitation session for a group of two o'clock students.

SUBJECTS

The subjects used in this study were 430 prospective elementary teachers enrolled in the Mathematics
105 course at The Ohio State University during the Winter Quarter, 1969. The subjects were predominantly female, of freshman or sophomore status. (See Table 1).

**TABLE 1**

**STUDENT BODY COMPOSITION FOR MATHEMATICS 105 WINTER QUARTER, 1969**

<table>
<thead>
<tr>
<th>Sex/Year</th>
<th>Freshman</th>
<th>Soph.</th>
<th>Junior</th>
<th>Senior</th>
<th>Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Female</td>
<td>150</td>
<td>141</td>
<td>89</td>
<td>15</td>
<td>9</td>
</tr>
</tbody>
</table>

The category "special" listed above was used to describe those prospective elementary school teachers who were studying at The Ohio State University under a post-degree program for teaching in elementary schools or who were enrolled at The Ohio State University in a limited retraining program to enable high school or special-area teachers to teach in the elementary grades. The former program is a special program designed to enable students who hold a baccalaureate degree from an accredited institution to meet the certification requirements to teach in an elementary school. There were six students in this category; one male and five females. The
latter program is designed for holder's of a currently valid provisional (or higher) high school or special teacher's certificate to obtain a retraining certificate valid for teaching in the elementary grades. There were four students in this program, all of whom were female.

The class composition referred to above was not similar to the class composition of previous Mathematics 105 classes. The percentage of freshmen and sophomores relative to the total number of members is lower than that of previous quarters. The enrollment figures for the winter quarter, 1968 showed that 93 percent of the 403 students enrolled in Mathematics 105 were of freshman or sophomore standing. The enrollment figures for winter quarter, 1969 showed that 72 percent of the 430 students were of freshman or sophomore standing. No apparent reason could be found for this redistribution of percentages.

INSTRUCTOR AND ASSISTANTS

As noted earlier, there was a course instructor and seven course assistants whose primary responsibility was the management of problem-solving sessions for the subjects. The course instructor, the experimenter, was a Ph.D. candidate in mathematics education. The
seven course assistants were four Ph.D. candidates in mathematics education and three mathematics department assistants who were not engaged in a post-degree program at the university. Three of the assistants had assisted in Mathematics 105 previously.

TREATMENTS

Assignment of Subjects

Random assignments of the 430 students to the experimental and control groups were not possible because the registration policy at The Ohio State University allows students to register for open classes of their own choice. The placement of students into the twelve or two o'clock classes was done by the Office of The Registrar and was not subject to experimental control. However, there was no reason to believe that undue experimental bias with respect to the experimental variables was introduced due to the absence of randomization. The matter of group equivalence will be discussed in the Design and Controls section of this chapter.

The size of the experimental section was 227 students. The size of the control section was 203 students. Each group met in large lecture halls
Monday, Wednesday and Friday. These lecture halls were of similar construction but were at different campus locations. The quality of lighting, seating, acoustics, chalkboard and comfort was very good for each section. There was no reason to suspect bias due to environmental circumstances.

The twelve o'clock recitation groups consisted of subjects randomly assigned from the twelve o'clock lecture population. The two o'clock recitation groups consisted of subjects randomly assigned from the two o'clock lecture population. This assignment took place the first day of the course. The students were asked to fill out a course registration form in the first lecture. These registration forms were used later in the day to assign each student to a recitation group. Class lists were then assembled and posted in four convenient locations throughout the campus. Each student was told in the first lecture session that these lists would be posted in the pre-arranged locations and that it was the student's responsibility to find his name on one of these lists. The students would then go, at the appointed time, to the section to which they were assigned. This procedure had become a standard operating procedure for Mathematics 105. The recitation assistants were supplied with
copies of the recitation assignments. These lists were their class roles.

The recitation groups met in various classrooms located throughout the campus. These classrooms varied somewhat in size, shape and structure because the classrooms were housed in different buildings. However, the quality of all fourteen classrooms was good.

**Assignment of Instructors and Course Assistants**

The same instructor taught the experimental and the control groups on Monday, Wednesday and Friday. The possibility of experimenter bias was recognized since the experimenter was also the instructor. However, the instructor attempted to insure consistency and uniformity of non-experimental variables. It was impossible to have two different instructors since the assignment of a single instructor to Mathematics 105 was the policy of the Mathematics Department and was not open to negotiation. In addition, the use of two different instructors would have presented the problem of intrasession history, that is, the irrelevant, unique events which occur in one session that do not occur in the other which could become rival hypotheses explaining the experimental versus control difference (1, 14).
The seven assistants to the course were randomly assigned to the twelve o'clock groups and again to the two o'clock groups by the instructor.

Assignment of Treatments

For future discussion purposes, the experimental group will be called group X and the experimental treatment will be called treatment X. Likewise, the control group will be called group C and the control treatment will be called treatment C.

There were only two groups of students; therefore, a flip of a coin was used to determine the experimental group. Group X was determined to be the twelve o'clock section; the two o'clock section then became group C.

Instructional Materials

Specially designed instructional materials were used with the experimental group. These materials consisted of 120 slide reproductions of student textbook pages, specially chosen for their relevancy to the Mathematics 105 content. The textbook pages chosen for reproduction were taken from three of six contemporary textbook series reviewed by the investigator. The textbook series were as follows:


These series were chosen for the following reasons:

1. the format of the student page lent itself well to large group presentation in that the topic being taught is presented at the top of the student page with exercises immediately afterwards. In essence, this means that the content of each student page is self-contained and can be reproduced to be projected onto a screen for large-group instructional purposes;

2. the number of words used to present a concept is minimal; hence, extensive reading is not required of the viewer. This, in turn, allowed the instructor more time than would be allowed with page reproductions from other series for explanations of the key concepts presented by the pages;

3. the pages chosen were decorative and appealing. The artwork when reproduced in
color is very impressive to adult and child alike;

4. each series has widespread use throughout the United States, hence increasing the relevancy of the daily presentation;

5. the content presented in these series was closely related to the Mathematics 105 content.

Once the pages for reproduction were chosen, they were then photographed using a Honeywell Pentax Spotomatic 35 mm. single-reflex-lens camera mounted on a special photographic apparatus provided by the Faculty of the Science and Mathematics Education of The Ohio State University. The film used was Kodak high speed Ektachrome (EX135). The film was developed and returned as picture slides.

The slide projector used to show the slides was a Sawyer 500 watt slide projector with slide tray controlled by a push button attachment. This projector was small, light and easily assembled.

The Experimental Treatment

There were twenty-six large-group lecture sessions held in Mathematics 105 during the winter quarter, 1969. The mathematics taught in each of these
sessions was of such a nature that most of the topics could be found in various modern elementary school textbooks in current use throughout the United States. The mathematics which was taught was described previously and a summary of the main topics can be found in Appendix D.

The experimental treatment consisted of teaching the mathematics course content, whenever possible, to group X by means of picture slide reproductions of specially selected student pages from the three elementary textbook series described in Instructional Materials. Not all the topics which were taught could be found in current elementary textbooks. Hence, not all the course content could be taught by slide reproductions. Appendix C lists the slides and topics which were used in the experiment.

Before describing the experimental treatment in great detail, it is necessary to describe the classroom in which the experimental treatment was conducted. The room was a large lecture room with seats for 260 students. The rows of seats were elevated with stairs leading to the back on both sides and up the middle of the classroom. The middle stairs separated the classroom into two sets of seats, each set consisting of 13 rows of 10 seats to a row. Students entered the
classroom through two sets of doors, one set on each side of the classroom. In the front of the classroom were chalkboards which extended from the one set of doors to the other. Over the front chalkboard was a projection screen which was lowered and raised by push button control. The lighting in the room was controlled by a dimmer instrument which regulated the intensity of the lighting. When the lighting was properly regulated, the screen could be clearly seen from all parts of the room. In short, the room was ideally equipped for photographic projection.

The acoustics in the room were adequate so that the instructor did not have to use a public address system while lecturing although such a system was available for use. To be sure that he was being heard clearly, the instructor from time to time asked if the students in the back rows could hear him. The only time that he could not be heard was when he was facing the blackboard. When this was pointed out to him he made it a point to write on the chalkboard and then explain his point while facing the group. This procedure corrected the difficulty.

Before each lecture, the instructor set up a slide projector on a stand positioned on the middle stairs. The projector was positioned to allow for
maximum screen utilization and clarity of picture. The slide projector also was focused before the start of class. The instructor then put a brief outline of the day's presentation on the front chalkboard. The day's lecture was begun with a few short introductory remarks before dimming the lights in the classroom and lowering the projector screen. One of the recitation assistants then operated the slide projector while the instructor discussed the contents of each slide.

The discussion of the contents of each slide was a critical part of the experiment. The instructor used a long pointer to call attention to various aspects of the reproduced page. For example, in presenting the notation of sets, the instructor pointed to the use of the braces on the fourth grade page and called attention to their use and meaning. After the concept was introduced, the instructor then called the student's attention to the exercises and asked them if they felt they could work the exercises. Time was then given to allow the students to work predetermined exercises from the page which had been projected onto the screen before them.

The experimentor continually stressed that the material which the students were seeing were pages from elementary textbooks which they, as elementary teachers
might someday be teaching. It was also emphasized that the material was the type material which was being studied by elementary school children.

The experimental treatment was not without initial difficulties in presentation. An uneasiness among the students was sensed during the first few days of the experiment whenever the lights were dimmed. Undoubtedly, the students had never been subjected to studying mathematics in the manner in which it was being presented. In short, the novelty of the presentation was somewhat disconcerting. This uneasiness seemed to diminish after the first week.

Initially, the instructor attempted to dim the lights immediately after the start of class and then project the slides onto the screen without any introductory remarks. Neither students nor instructor found this procedure to be beneficial. By using this procedure, there was no time for developmental teaching or learning. The material was simply there before the students without benefit of discovery or explanation. The experimental procedure was then modified to include a brief lead-in by the instructor to new topics. Sometimes this involved turning on the lights and rolling the screen back up. Other times, the screen was left down and a few of the lights were turned back on
while the introductory remarks were made. This readjustment of procedure seemed to work better.

There was also a problem during the first week with the projection of the slides. The room was not completely darkened. Hence, the students in the back rows of the room could not read the material projected onto the screen. This problem was resolved by completely dimming the lights. There was also a concern about the difficulty the students might have in taking notes. Interviews with various students convinced the instructor that notes could and were being taken in the darkness. The room was somewhat lighted by the slide projector so there was not complete darkness.

Exercises were assigned at the conclusion of each presentation. The exercises were either from the basic text or from the handouts described earlier. These exercises were then reviewed in the recitation sessions, by the recitation assistants.

The topics taught in Mathematics 105 were not all to be found in modern elementary school textbooks. Those topics which were missing from the elementary school textbooks were what might be considered as in-depth topics related to basic mathematical concepts. For example, there was one unit in Mathematics 105 which consisted of two lectures on the definition and
properties of various binary operations such as $a^* b = 2a - 3b$. No elementary textbook pages were found which treated these topics. Hence, these two sessions were conducted in the same manner in both experimental and control groups.

It is impossible to state specifically how much of the 48-minute lecture time was devoted to the discussion of the page reproductions. The amount of time spent was a function of the availability of a student textbook page for the topic which was being presented and a function of the amount of amplification given to the material appearing on the student page. For example, a slide was projected onto the screen which showed by means of number line illustrations that the set of fractional numbers is ordered. The instructor amplified the concept of ordering fractional numbers by using this concept to illustrate another property of the fractional numbers, that is, that they are also dense. There were days when only one or two slides were used in the presentation. The remainder of the presentation was conducted by lecture. Reference to Appendix C represents the number of slides used in each presentation.
Control Treatment

Group C, the control group, was taught the same mathematical topics as the experimental group. The method of instruction was the lecture method without the slide reproductions.

It is worthwhile to describe the lecture hall in which the control treatment was conducted. The room was a large lecture hall with seats for 240 students. The rows of seats were divided into 2 sets of seats in the same manner as were the experimental treatment rows. Students entered the room from the back and found their seats by walking down three sets of stairs, one on each side of the room and one down the middle of the room. In the front of the classroom were two sets of chalkboards both of which could be raised or lowered by a switch positioned to the side of the chalkboards. There were public address facilities and light control switches, neither of which were used by the lecturer. For all intents and purposes, the room was similar to the room used in the experimental treatment.

The instructor outlined each day's lesson on the chalkboard in the same manner as he did in the experimental treatment. The instructor then presented
the day's lesson by means of a lecture presentation. The presentation of the mathematical topics relied heavily upon the use of the chalkboard. The illustrative examples that were chosen were similar to the illustrative examples that the experimental group had seen in the page reproduction. After the introduction and explanation of a topic, the instructor had the students work examples similar to those examples which he requested the experimental group to work from the reproduced student page. No direct reference was made to the occurrence of these topics or exercises in current elementary school textbooks. At the end of each lecture, exercises were assigned from the text being used in the course. The textbooks and the exercises were the same as those assigned to group X. The course assistants reviewed these exercises during the two o'clock recitation meetings.

The raising and lowering of the projection screen in the experimental group was somewhat distracting. The same can be said for the raising and lowering of the chalkboards in the control treatment. As the instructor lectured, there was a need for the use of both sets of boards; hence, one set of boards was raised and then lowered when the second set of boards was filled with information. The second set
was then raised. This was construed as equivalent to the distraction of the raising and the lowering of the screen.

The mode of lecture presentation in either the experimental or control treatment did not prohibit the asking of questions by the students. The number and type of questions asked in each group appeared to the investigator as being quite similar. The students in each group were reluctant to ask questions. When questions were asked, they were answered directly by the instructor. Questions were not encouraged but they were answered when asked provided they were not questions regarding the homework assignment. The students were told in both sections that questions regarding the homework were to be answered in their recitation sections.

As mentioned previously, a common examination was given to both group X and group C on each of 4 different occasions. These examinations were used for student evaluation purposes and were given by the recitation assistants to group X and group C at the same time and in the same examination room. Each set of examinations was graded by the same person, the recitation instructor.
Design and Controls

Because of the inability to sample randomly subjects and to assign randomly subjects to treatments, a non-equivalent control group design was used (1, 47-51).

Attitude and achievement pretests were used to assess the degree of similarity of the two groups with respect to the dependent variables and to provide data which would later be used to interpret the effect of treatments upon the dependent variables. The attitude and achievement pretest data were used as covariates in the analysis of covariance model (See Chapter III).

The same attitude test (Appendix B) was given to each group the first day of the course in the lecture sessions. The attitude test was given at the beginning of the period after a few introductory remarks by the instructor. The students were told that the instructor was interested in assessing the attitudes of prospective elementary school teachers towards mathematics and the instructor asked the students' cooperation in taking the test. They were asked to be as honest as possible and were told that their responses would in no way be used for anything other than
attitude assessment. The students were not told that they would be tested again at a later date. The students were given ten minutes to complete the test and the tests were then collected. The same directions and procedures were used with each group.

The same attitude test was used as a posttest. This test was administered to each group in the penultimate lecture session. This session was chosen to maximize the number of students present for the posttest. It was quite possible that there would have been a greater number of absentees on the last day of the course.

Each group was given the same achievement pretest. This test was administered by the assistants in the first recitation session. A set of testing instructions was issued to each assistant. The need for uniformity of testing was emphasized to each assistant. A written statement was read to the students by the assistants before the testing was begun. The purpose of the statement was to assure the students that the test which they were to take was designed to measure the students' knowledge of the Mathematics 105 course content. It was mentioned that the motivation for giving this test was to obtain information for designing the course and that the achievement pretest
would not be used in determining the students' grade. The assistants emphasized that the students would be seeing test items over content that they probably had not seen before and that they would not be expected to be able to answer all the test items correctly. The students were asked to do their best on the examination and were allowed the full period to take the test.

The achievement pretest was also the first part of the students' final examination. Therefore, the pretest copies were numbered and accounted for by the recitation assistants. All scratch paper, which was provided by the assistants, was collected.

After the first 48 minutes of the final examination, the posttest was collected. Part two of the final examination was then handed out.

The experimenter graded the attitude pre- and posttests and the achievement pretest in order to control instrumentation, the nonexperimental variable which results from differences in conducting, scoring and/or changing the test. The achievement posttest was machine-scored.

Since the assistants knew that the pre- and posttests in achievement were to be the same, there was the possibility that the assistants may have
consciously or subconsciously taught for the test. This would have introduced bias into the experiment. To control this variable, each assistant was asked not to examine the test. It was explained to each assistant that their knowledge of the test could influence their answers to questions asked by the students during the quarter. The need for their cooperation was stressed. There was no reason to doubt that the assistants cooperated in this matter.

The question can be raised as to whether or not prior knowledge of the posttest influenced the teaching of the instructor who was also the experimenter. The pre- and posttest was constructed and proof-read three weeks before the test was first administered. The experimenter did not examine the test contents again until after the posttest administration. Since the test was a multiple-choice test, the scoring key was designed to enable the grading of correct letters, not correct statements, when the pretest results were scored. The degree to which the experimenter forgot the test items is considered a limitation of the study.

The results of the attitude and achievement pretests were not divulged either to the students or to the assistants. Neither the students nor the
assistants saw the achievement test again until the final examination. Informal interviews with several students after the achievement posttest had been administered provided evidence that the subjects had forgotten the contents of the pretest and that they did not expect to see its contents again. Several of the students who were interviewed did not realize that the achievement pre- and posttests were the same.

A ten percent random sample from each of the groups was taken to examine the variable of student mathematical ability. The evidence considered encompassed previous high school courses in mathematics and the grades, previous college or university courses in mathematics and the grades, the student placement level scores in mathematics as determined by The Ohio State University Mathematics Placement Examination and ACT scores in mathematics. The high school and grades were obtained from the registration forms which the students were asked to complete during the first lecture session. The placement level data and ACT scores were obtained from The Ohio State University Testing and Orientation Center.

It was hypothesized that if a significant difference with respect to the variable of mathematical ability existed between the two groups, such a
difference would show up in a random sample of each population. The results of this analysis are in Chapter Three. This analysis revealed no significant difference between groups with respect to the variable of mathematical ability.

Two other aspects of the subjects which were examined were sex and class standing. These data were obtained from the course registration forms and are reported in Table 2.

TABLE 2

STUDENT BODY COMPOSITION FOR THE EXPERIMENTAL AND CONTROL GROUPS

<table>
<thead>
<tr>
<th>Sex/Year</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
<th>Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Female</td>
<td>65</td>
<td>85</td>
<td>46</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>X</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C.</td>
<td>85</td>
<td>56</td>
<td>43</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

The non-equivalent control group design controlled the main effects of history, that is, the differences which occurred in the two groups due to a function of time. The control of intrasession history was enhanced by teaching the same mathematical content by
the same instructor to both groups in similar class-
rooms.

Neither group was told by the instructor or the
assistants that they were subjects of an experiment
although it is reasonable to assume that some students
knew that the instruction differed in the two sections.

There way no feasible way of controlling the
effects of students attending Mathematics 105 lectures
other than their own. Attendance could not be taken
due to the size of the groups. The class meeting time
of group X and the nonavailability of seats helped to
prevent the mixing of groups. Group X met at the noon
mealtime of many students. There were 260 seats in
the noon lecture room, 227 of which should have been
occupied by students regularly scheduled for the
course at that time.

A questionnaire was constructed for each section
(see Appendices H and I) which asked whether or not
each student had attended the lecture section to which
he had not been assigned. This questionnaire was
handed out and completed at the end of the eighth week
of the course. The results of the responses to this
question are reported in Table 3.
TABLE 3
RESPONSES TO THE QUESTION: DID YOU ATTEND A LECTURE SECTION OTHER THAN YOUR OWN?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Absentees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>17</td>
<td>195</td>
<td>11</td>
</tr>
<tr>
<td>Control</td>
<td>34</td>
<td>154</td>
<td>9</td>
</tr>
</tbody>
</table>

Each student who replied that he had attended the lecture to which he had not been assigned was asked to estimate the number of times he had attended the other section. A summary of these results appears in Table 4.

TABLE 4
ESTIMATES OF ATTENDANCE IN A LECTURE SECTION OTHER THAN THAT ASSIGNED

<table>
<thead>
<tr>
<th>Number of Times</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>15</th>
<th>20</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Students in C</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No. of Students in X</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The degree to which the students were truthful in completing this questionnaire and the exposure of students to lecture sections other than their own are
recognized as limitations of the study.

TESTS AND MEASURES

Attitude

The attitude pre- and posttest was a Likert-type attitude instrument modified and standardized for the Mathematics 105 population by Shatkin as part of his doctoral research (72). The reliability of the instrument was .972.

Achievement

A major objective of this study was to measure achievement by the students enrolled in Mathematics 105. No appropriate standardized test was found to measure achievement in the content taught in this course. Therefore, an instrument (see Appendix A) was constructed to measure the desired content. The test was a combination of test items from many sources each of which is recognized in Appendix F.

The choice of items for test inclusion was heavily influenced by an article written by Marion G. Epstein (31, 311-20) in which six levels of intellectual abilities are described. This taxonomy is a refinement of the Bloom taxonomy.
The ordering of the test items was random. Hence, the test items were not deliberately arranged in an increasing order of difficulty.

The attempt to validate the achievement instrument involved the criticisms of a validating team which included professors from the Department of Mathematics and from the Faculty of Mathematics Education at The Ohio State University (see Appendix E).

The first draft of the test was criticized by the four members of the validation team and by five graduate students in mathematics education. Their constructive criticisms were then incorporated into a revised draft, which was criticized again by the validating team. A final draft was prepared. This draft was the examination given as the achievement pre- and posttest.

The reliability of the achievement instrument is analyzed in Chapter Three.
CHAPTER III
ANALYSIS AND INTERPRETATION OF THE DATA

This chapter of the dissertation first presents a partial description of the mathematical background of the students involved in the study. While this description was incomplete and, to a great degree, subjective, it was offered in an attempt to provide additional information regarding the variable of previous mathematical achievement. Previous mathematical data such as high school and college courses and grades, American College Test scores in mathematics and The Ohio State University mathematics placement level scores were used in this description.

Next, the attitude and achievement data were analyzed by means of a multivariate analysis of covariance. Finally, the statistical analyses were interpreted and related to the hypotheses put forth in Chapter I.

ANALYSIS OF SUBJECTS' MATHEMATICAL BACKGROUND

Since a random assignment of subjects to the experimental and control treatments was not feasible,
an analysis of the mathematical backgrounds of a ten percent random sample of the subjects from each group was performed. This analysis should be considered as incomplete and inconclusive due to the absence of a standardized instrument or scale with which to compare the two groups.

The American College Test scores in mathematics used in this analysis were obtained while the subjects were seniors in high school. Many of the subjects in each group could quite possibly have studied additional mathematics courses or other mathematics-related courses after entry to the university, but before enrollment in Mathematics 105. This could increase mathematical proficiency thus invalidating the use of the ACT score to measure mathematical proficiency at the time of enrollment in Mathematics 105. A second reason for not having used ACT scores to evaluate group equivalence was that ACT scores were not available for all the subjects considered in the study. ACT scores were not required of transfer students to the university; hence, several ACT scores were missing. Incomplete data resulted.

A similar argument could be used to show that the use of the mathematics placement scores, obtained upon entry to the university, were insufficient for
the comparison of the experimental and control groups. Additional coursework in mathematics or mathematics-related courses could invalidate the use of the mathematics placement results for comparative purposes.

The presentation and analysis of the data in the first part of this chapter was an attempt to provide additional information about, and insight into, the mathematical background of the subjects. No conclusions could be drawn regarding the equivalence of the groups with respect to the variable of previous mathematical achievement.

High School and College Courses and Grades

The first measure of prior mathematical achievement was high school and college courses and grades. The numerical quantity representing each student's grades was obtained by adding one point for each D earned in a high school course pursued for one year or in a college course pursued for one quarter, two points for each C earned, three points for each B earned and four points for each A earned. There was no distinction made between the level of mathematics taught in each course. One was a minimum numerical score since the State of Ohio requires at least one year of mathematics for graduation from high school.
The distribution of grades using this numerical evaluation is described in Table 5. The difference in preparation favored the experimental group but, as summarized in Table 5, the t-statistic was not significant at the .05 level.

The use of an analysis of variance to analyze the subjective data of the high school and college courses and grades was statistically inappropriate. The scales upon which the achievement data were measured presumably were not the same for each student. What constituted achievement for an A in one school could differ considerably in a different school. Also, the differences in the content of the various courses was not taken into consideration in determining the numerical quantity used as data. These disparities were recognized as limitations of the analysis.

**TABLE 5**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>P Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>23</td>
<td>9.7</td>
<td>3.7</td>
<td>0.275</td>
<td>n.s.</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>9.4</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACT Scores

The ACT mathematics scores were used as a measure of prior mathematical achievement. Of the 43 students in the combined random samples, ACT scores were available for only 37 students. There were three transfer students in each of the samples for whom ACT scores were not available. The distribution of the ACT scores for each group is shown in Table 6. The t-statistic as shown in Table 6 was not significant at the .05 level.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>P Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>20</td>
<td>22.0</td>
<td>3.9</td>
<td>-.381</td>
<td>n.s.</td>
</tr>
<tr>
<td>C</td>
<td>17</td>
<td>22.5</td>
<td>4.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mathematics Placement Scores

As described on page 28, each student upon entering The Ohio State University was placed at one of five mathematics levels depending upon his achievement as measured by one of two different mathematics placement examinations. The numerical quantity used
to represent each student's placement level was either the student's score on the B-test of the placement examination or an equivalent score on the B-test derived from the student's score on the D-test of the placement examination. The range of possible scores on the B-test was 0 to 40. Table 7 describes the distribution of the placement scores using the numerical evaluation. The difference in mathematical preparation as measured by the mathematics placement examinations favored the experimental group but as summarized in Table 7, the t-statistic was not significant at the .05 level.

**TABLE 7**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-statistic</th>
<th>P Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>23</td>
<td>25.2</td>
<td>7.0</td>
<td>.481</td>
<td>n.s.</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>24.1</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ANALYSIS OF THE STATISTICAL MODEL**

A multivariate analysis of covariance computer

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3 The equivalent D-test scores were prepared for the experimenter by Dr. Robert W. Ullman, Director of the Testing and Orientation Center, The Ohio State University.
program, designed by the University of Miami Biometric Laboratory (2, 20-39) was used on the following data collected on the subjects enrolled in Mathematics 105, Winter Quarter, 1969:

1. subjects' Mathematics 105 achievement pretest score;
2. subjects' Mathematics 105 achievement posttest score;
3. subjects' Mathematics 105 attitude pretest score;
4. subjects' Mathematics 105 attitude posttest score;
5. subjects' Mathematics 105 recitation instructor; and,
6. subjects' Mathematics 105 method of instruction.

The independent variables in this design were methods of instruction (treatments X and C) and recitation instructors. The dependent variables were achievement and attitude.

The analysis of covariance model was given by the equation

\[ Y_{ij,k} = \mu + S_i + T_j + SI_{ij} + B_1X_{1i,j} + B_2X_{2i,j} + E_{i,j,k} \]

\[ i = 1, 2 \quad \text{and} \quad j = 1, 2, \ldots, 7 \]
where $Y_{i,j,k}$ is the dependent variable score for the $k$ student in method $i$ with recitation instructor $j$ and where

1. $\mu$ is the overall Mathematics 105 dependent variable mean score;
2. $S_i$ is the effect for the $i^{th}$ method ($i=1,2$);
3. $T_j$ is the effect for the $j^{th}$ instructor ($j=1,2,\ldots,7$);
4. $ST_{i,j}$ is the interaction effect of method $i$, with instructor $j$;
5. $X_{1,i,j,k}$ is the achievement pretest raw score for the $k$ student in method $i$, with recitation instructor $j$ and $B_1$ is the associated regression coefficient;
6. $X_{2,i,j,k}$ is the attitude pretest raw score for the $k$ student in method $i$, with recitation instructor $j$ and $B_2$ is the associated regression coefficient; and,
7. $E_{i,j,k}$ is the error adjustment for the $k$ student in method $i$, with recitation instructor $j$.

In summary, the model expresses the individual student's attitude and achievement scores as a function of the overall dependent variable posttest raw score mean, the effect for method, the effect for recitation instructor, the interaction effect of method
and instructor, effects for the concomitant variables of attitude and achievement pretest scores, and an error term.

While this study was primarily concerned with the effects of methods upon achievement and attitude, the effects of instructor and the interaction of instructor and method were also considered in the statistical model to more reliably interpret the effects of method upon the dependent variables. For a more complete discussion of factorial analysis see Kerlinger (15, 213-239).

The assumptions implicit in, and the applicability of, this model are discussed by Winer (24, 578-588). The use of an analysis of covariance instead of the use of an analysis of simple gain scores is recommended by Campbell and Stanley (1, 49).

ANALYSIS OF THE ACHIEVEMENT DATA

Regression Coefficients

The regression coefficients (the covariate adjustment coefficients) in the covariance model for the variable of posttest achievement were tested for significance using an univariate F-test. In particular, the null hypothesis that $B_1 = B_2 = 0$ was tested
with respect to the variable of achievement. As shown in Table 10, the F-statistic was significant at the .001 level. Hence, the hypothesis that $B_1 = B_2 = 0$ was rejected and the covariates of attitude and achievement pretest scores remained in the covariance model.

Methods, Instructors and Interaction

The analysis of covariance model was applied to the Mathematics 105 student population, Winter Quarter, 1969. The number of subjects in each recitation section and in each method is shown in Table 8. Of the 450 students who enrolled in Mathematics 105, complete data were available for 406 students. Ten students dropped the course (4 in group X; 6 in group C); nine students entered the course after the achievement pretest was given (7 in group X; 2 in group C); three students, all in group X, did not take the attitude pretest; and two students, all in group X, were graduating seniors who did not take the achievement posttest.
TABLE 8

AVAILABLE DATA FOR METHOD AND INSTRUCTOR

<table>
<thead>
<tr>
<th>Method</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>30</td>
<td>31</td>
<td>28</td>
<td>32</td>
<td>32</td>
<td>30</td>
<td>28</td>
<td>211</td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>30</td>
<td>24</td>
<td>33</td>
<td>25</td>
<td>27</td>
<td>27</td>
<td>195</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>61</td>
<td>52</td>
<td>65</td>
<td>57</td>
<td>57</td>
<td>55</td>
<td>406</td>
</tr>
</tbody>
</table>

Table 9 gives the unadjusted mean achievement pre- and posttest scores.

TABLE 9

UNADJUSTED MEAN SCORES* ACHIEVEMENT

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Method X Pretest</th>
<th>Posttest</th>
<th>Method C Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.733</td>
<td>28.867</td>
<td>15.138</td>
<td>29.690</td>
</tr>
<tr>
<td>2</td>
<td>13.452</td>
<td>29.710</td>
<td>14.300</td>
<td>29.133</td>
</tr>
<tr>
<td>4</td>
<td>14.937</td>
<td>29.687</td>
<td>15.152</td>
<td>28.667</td>
</tr>
<tr>
<td>5</td>
<td>14.594</td>
<td>28.250</td>
<td>13.720</td>
<td>27.760</td>
</tr>
<tr>
<td>6</td>
<td>15.667</td>
<td>29.333</td>
<td>15.667</td>
<td>27.593</td>
</tr>
<tr>
<td>7</td>
<td>15.786</td>
<td>28.571</td>
<td>14.519</td>
<td>29.407</td>
</tr>
<tr>
<td>Overall</td>
<td>14.758</td>
<td>28.587</td>
<td>14.938</td>
<td>28.466</td>
</tr>
</tbody>
</table>

The following hypotheses regarding achievement were tested using the covariance model:
\[ H_0: \ S_1 = S_2 = 0 \]
\[ H_1: \ T_1 = T_2 = \ldots = T_7 = 0 \]
\[ H_2: \ ST_{1,1} = ST_{1,2} = \ldots = ST_{2,7} = 0 \]

The data resulting from the testing of these hypotheses is summarized in Tables 10 and 11.

### TABLE 10

**ANALYSIS OF COVARIANCE * ACHIEVEMENT**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
<th>F</th>
<th>P Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>1642.794</td>
<td>821.397</td>
<td>62.026</td>
<td>.001</td>
</tr>
<tr>
<td>Methods (S_i)</td>
<td>1</td>
<td>1.712</td>
<td>1.712</td>
<td>0.129</td>
<td>.719</td>
</tr>
<tr>
<td>Instructors (T_j)</td>
<td>6</td>
<td>608.298</td>
<td>101.383</td>
<td>7.656</td>
<td>.001</td>
</tr>
<tr>
<td>Interaction (ST_{i,j})</td>
<td>6</td>
<td>75.894</td>
<td>12.649</td>
<td>0.955</td>
<td>.455</td>
</tr>
<tr>
<td>Within Cells (error)</td>
<td>390</td>
<td>5164.380</td>
<td>13.242</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### TABLE 11

**CONTRASTS (EFFECTS FOR S_i AND T_j) * ACHIEVEMENT**

<table>
<thead>
<tr>
<th>Method (S_i)</th>
<th>Instructor (T_j)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1 = 0.077</td>
<td>T_1 = 0.734 T_4 = 0.469 T_7 = 0.508</td>
</tr>
<tr>
<td>S_2 = -0.077</td>
<td>T_2 = 1.489 T_5 = -0.095</td>
</tr>
<tr>
<td></td>
<td>T_3 = -2.796 T_6 = -0.309</td>
</tr>
</tbody>
</table>
As indicated in Table 10, the F-statistics obtained in testing the effects of methods and the effects of interaction of methods and instructors upon posttest achievement were not significant. Therefore, hypotheses, $H_0$ and $H_2$, were not rejected at the .05 significance level. There was a significant effect of instructors upon achievement at the .001 level. Hence, the hypothesis, $H_1$, was rejected at the .001 significance level.

From Table 11, it is observed that, quantitatively, method 1 (treatment X) produced the positive effect of adding 0.077 points to a student's Mathematics 105 achievement posttest score while method 2 (treatment C) produced the negative effect of subtracting 0.077 points from a student's achievement posttest score. These different effects were not significant at the .05 level.

**ANALYSIS OF THE ATTITUDE DATA**

**Regression Coefficients**

The regression coefficients for the covariates of achievement and attitude pretest scores in the covariance model for the variable of attitude were tested for statistical significance using an univariate $F$-test. The null hypothesis that $B_1 = B_2 = 0$ was
tested with respect to attitude. As shown in Table 13, the F-statistic was significant at the .001 level. Hence, the hypothesis that $B_1 = B_2 = 0$ was rejected and the covariates of attitude and achievement pre-test scores remained in the covariance model for attitude.

Methods, Instructors and Interaction

The analysis of covariance model for attitude was applied to those subjects described in Table 8, page 68. The unadjusted mean attitude pre- and post-test scores are given in Table 12.

| Instructor | Method X | | Method C | | | |
|---|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest | |
| 1 | 66.267 | 72.100 | 72.448 | 75.483 | |
| 2 | 65.645 | 71.839 | 64.200 | 69.633 | |
| 3 | 75.893 | 81.321 | 69.625 | 74.833 | |
| 4 | 76.781 | 83.406 | 68.636 | 72.848 | |
| 5 | 67.594 | 73.156 | 64.920 | 70.280 | |
| 6 | 70.467 | 76.000 | 63.259 | 67.296 | |
| 7 | 61.929 | 71.571 | 67.852 | 76.407 | |
| Overall | 69.270 | 75.644 | 67.312 | 72.384 | |
The following hypotheses were tested using the covariance model:

\[ H_0^1: S_1 = S_2 = 0 \]
\[ H_1^1: T_1 = T_2 = \cdots = T_7 = 0 \]
\[ H_2^1: ST_{1,1} = ST_{1,2} = \cdots = ST_{2,7} = 0 \]

The data resulting from the testing of these hypotheses is summarized in Tables 13 and 14.

**TABLE 13**

**ANALYSIS OF COVARIANCE *ATTITUDE**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
<th>F</th>
<th>P Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>94,245.262</td>
<td>47,122.631</td>
<td>387.264</td>
<td>.001</td>
</tr>
<tr>
<td>Methods (S_i)</td>
<td>1</td>
<td>378.578</td>
<td>378.578</td>
<td>3.111</td>
<td>.079</td>
</tr>
<tr>
<td>Instructors (T_i)</td>
<td>6</td>
<td>611.154</td>
<td>101.859</td>
<td>0.837</td>
<td>.542</td>
</tr>
<tr>
<td>Interaction (S,Tij)</td>
<td>6</td>
<td>339.042</td>
<td>56.507</td>
<td>0.464</td>
<td>.835</td>
</tr>
<tr>
<td>Within cells (error)</td>
<td>390</td>
<td>47,460.270</td>
<td>121.693</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As indicated in Table 13, the F-statistics obtained in testing the effects of method, the effects of instructor and the effects of interaction of method and instructor upon attitude were not significant at
the .05 level. Therefore, hypotheses, $H_0$, $H_1$, and $H_2$, were not rejected at the .05 level.

**TABLE 14**

**CONTRASTS (EFFECTS FOR $S_1$ AND $T_j$) *ATTITUDE**

<table>
<thead>
<tr>
<th>Method $S_1$</th>
<th>Instructor ($T_j$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1 = 0.956$</td>
<td>$T_1 = -1.041$ $T_4 = 0.863$ $T_7 = 2.255$</td>
</tr>
<tr>
<td>$S_2 = -0.956$</td>
<td>$T_2 = -0.512$ $T_5 = -0.593$</td>
</tr>
<tr>
<td></td>
<td>$T_3 = 0.727$ $T_6 = -1.699$</td>
</tr>
</tbody>
</table>

From Table 14, it is observed that quantitatively, method 1 (treatment X) produced the positive effect of adding .956 points to a student's Mathematics 105 attitude posttest score while method 2 (treatment C) produced the negative effect of subtracting .956 points from a student's attitude posttest score. These different effects were not significant at the .05 level.

**ANALYSIS OF THE AUTHOR'S ACHIEVEMENT TEST**

The author's achievement test was constructed because a standardized test measuring achievement in the material taught in Mathematics 105 could not be found. The achievement test consisted of 43 multiple
choice items. The validity of the test was discussed in Chapter I. The reliability of the test as determined by Kuder-Richardson 20 and 21 tests was 0.653 and 0.502 respectively. A summary of the test statistics appears in Appendix G.

INTERPRETATION OF THE DATA

Subjects' Background

On the basis of the analysis of the data of high school and college courses and grades, ACT scores in mathematics and the mathematics placement scores, no significant differences in previous mathematical achievement were found. However, the equivalence of the experimental and control groups with respect to prior mathematical achievement cannot be concluded from these analyses for the reasons cited earlier in this chapter.

Effects of Methods Upon Achievement

While the difference in achievement in Mathematics 105 as measured by the author's achievement test favored the experimental group, there was no support in the data yielded by the achievement test for the hypothesis that there was a significant
difference between treatment X and treatment C with respect to mathematical achievement in Mathematics. Consequently, $H_0$, the null hypothesis, was not rejected. There was no significant difference in mathematical achievement between the two treatments.

**Effect of Methods Upon Attitude**

The difference in attitude towards mathematics as measured by the Shatkin instrument favored the experimental group. However, the data yielded by the attitude test did not support the hypothesis that there was a significant difference between treatment X and treatment C with respect to attitude towards mathematics. Consequently, $H_0$, the null hypothesis was not rejected. There was no significant difference in attitude towards mathematics between the two treatments.

**Effect of Instructor Upon Achievement and Attitude**

It was shown in the analysis of the data that there was a significant effect of instructors upon achievement but not upon attitude. Because this study was concerned with the independent variable of methods, no elaboration of interpretation of instructor effect upon achievement and attitude was rendered.
Effect of Interaction of Instructors and Methods Upon Achievement and Attitude

The interactive effect of instructors and methods upon achievement and attitude was not found to be statistically significant. This lent tenuous support to the hypothesis that bias was not introduced into the experiment by the assignment of the instructors to the recitation groups used in the experiment.

This concludes the analysis and interpretation of the data put forth in this chapter. Other data gathered during the experiment will be presented in the next chapter to amplify the results of the experiment.
CHAPTER IV

ADDITIONAL INFORMATION RELATED TO THE STUDY

There were additional data gathered during the experiment which, while not necessarily relevant to the hypotheses put forth in Chapters I and II, provided information that might be useful in amplifying the results of the experiment. Much of the data will be described without the benefit of statistical analysis.

QUESTIONNAIRE RESULTS

Two questionnaires were designed by the experimenter for the purpose of obtaining additional information regarding the experiment. The first questionnaire (Appendix H) consisted of ten questions and was administered to the experimental group at the end of the eighth week of the experiment. Two hundred and sixteen of the two hundred and twenty-three students regularly scheduled for this section answered the questionnaire.

The second questionnaire (Appendix I) consisted of five questions and was administered to the control
group on the same day that the first questionnaire was administered to the experimental group. These five questions were the same as the last five questions of the experimental group questionnaire. One hundred and eighty-eight of the one hundred and ninety-seven regularly scheduled for this section answered the questionnaire.

A description of the results of the responses to each of these questions follows.

Student Reaction to the Experimental Treatment

The first five questions appeared only on the experimental group questionnaire and were designed to sample class reaction to the experimental treatment.

Question one stated, "Would you have preferred that this course be taught completely by lecture without the slide presentation?" An analysis of the responses to this question (See Table 15) showed a decisive endorsement of the experimental treatment.

Question two was designed to determine whether or not the students felt that too much time was being spent on the slide presentation. The question was asked, "Do you feel that the slide presentation was overdone, that is, that the slides were overemphasized or that too much time was spent on them?" Table 15
shows the responses to this question. These responses indicate that the students did not feel that too much time was spent in the presentation of the material by means of slides.

Question three was included in the questionnaire as a result of informal interviews which the experimenter had with various students in the experimental group. Each student was asked informally whether he felt the slide presentation was worthwhile, that is, was the presentation helpful in learning the course content? One of the students responded, "I can't understand what the author is trying to say in the book (our text) but I can understand what is being said to the kids." The responses of the group to the question, "Do you feel that the slide presentation was helpful in learning Mathematics 105?" are listed in Table 15.

Questions four and five are related questions. It was hypothesized in Chapter I that if the mathematical content of Mathematics 105 could be related to the content of the elementary school curriculum, the students would feel a need to learn mathematics; hence, significant achievement in mathematics would occur. Question five asked, "Did the slide presentation relate the course content to that of the
elementary school curriculum?" Question four asked, "Did the slide presentation cause you to feel a need to learn mathematics?" The responses to these questions as shown in Table 15, indicate that while 209 students felt that the slide presentation related the course content to the elementary school curriculum, only 110 students felt that the slide presentation caused them to feel a need to learn mathematics. A conjecture explaining this disparity of responses is put forth in Chapter V.

TABLE 15

STUDENT RESPONSES * QUESTIONS 1-5

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>176</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>57</td>
<td>146</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>162</td>
<td>34</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>110</td>
<td>77</td>
<td>29</td>
</tr>
<tr>
<td>5</td>
<td>209</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Student Selection of Additional Mathematics Courses

It was hypothesized by the experimenter that, if the experimental treatment was effective in relating the course content to the future classroom needs of the prospective elementary school teacher, more students
in the experimental group would elect additional mathematics courses than would students in the control treatment who did not have the content related to the elementary school curriculum. Such was not the case. Table 16 shows the responses to questions 6 and 7 which asked the students whether or not they were either enrolled in, or planning to enroll in, additional mathematics courses designed for the prospective elementary school teacher. Thirty percent of the students in the control group and nineteen percent of the students in the experimental group responded that they had enrolled in Mathematics 107, an informal geometry course for elementary school teachers. Thirty-three percent of the control group and twenty-three percent of the experimental group responded that they were planning to take Mathematics 106, a mathematics course for prospective elementary which extends the mathematics presented in Mathematics 105. It seems evident, a greater percent of students in the control group elected to pursue additional mathematics courses than did students in the experimental group.
TABLE 16

STUDENT RESPONSES • ADDITIONAL MATHEMATICS COURSES

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Yes X</th>
<th>Yes C</th>
<th>No X</th>
<th>No C</th>
<th>Undecided X</th>
<th>Undecided C</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>40</td>
<td>57</td>
<td>172</td>
<td>131</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>49</td>
<td>62</td>
<td>114</td>
<td>30</td>
<td>49</td>
<td>46</td>
</tr>
</tbody>
</table>

Student Selection of Teaching Level

The students were asked in question eight at which grade level they were planning to teach upon graduation. This question was asked to obtain data for future research. Kane (39, 174) hypothesized that prospective teachers with relatively unfavorable attitudes towards mathematics tend to prefer teaching assignments in the primary grades while those who have the most favorable attitudes toward mathematics tend to prefer assignments in the intermediate grades. The data resulting from the responses to question eight will enable the author to test, at a later date, Kane's hypothesis. Also, a similar hypothesis will be tested with respect to favorable achievement in mathematics and choice of teaching level. The responses to question eight are summarized in Table 17.
When asked in question nine if the slide presentation (lecture presentation) influenced their choice of teaching level, 89 percent of the experimental group answered no. Eighty percent of the control group answered no. This question was designed to determine whether or not an awareness of the elementary school mathematical content would encourage the more able students to choose a high level of teaching than that chosen by the less able students. On the basis of the student responses in each group the treatment did not appear to influence their choice of grade level.

**TABLE 18**

**STUDENT RESPONSES * INFLUENCE OF TREATMENT**

<table>
<thead>
<tr>
<th>Group</th>
<th>Yes</th>
<th>No</th>
<th>Undecided</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>13</td>
<td>188</td>
<td>11</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>148</td>
<td>25</td>
</tr>
</tbody>
</table>
The description of, and response to, question ten was described on page 55.

COURSE GRADES

The experimental and control groups were compared with respect to achievement in Mathematics 105 as measured by an instrument constructed by the experimenter. In Chapter III these results were analyzed and were shown not to be significant. Another measurement of student achievement was given by the course grades attained by the students in each group. A subjective comparison of those grades (see Table 19) revealed that there did not appear to be significant differences in the groups with respect to grades given in Mathematics 105. If 5 points were given for each A, 4 points for each B, 3 points for each C, 2 points for each D and 1 point for each E, the mean scores for groups X and C would be 3.345 and 3.350 respectively. This subjective interpretation of the Mathematics 105 grades would appear to support the interpretation of the data in Chapter III with respect to achievement.
TABLE 19

COURSE GRADES

<table>
<thead>
<tr>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>13</td>
<td>69</td>
<td>124</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>62</td>
<td>101</td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>

This concludes the report of the supplementary data obtained during the course of the experiment. The conclusions, limitations and recommendations resulting from the conduct of the experiment will be presented in Chapter V.
CHAPTER V

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

The experiment described in this dissertation was an attempt to provide a partial answer to the question of how methodology in the teaching of mathematics to prospective elementary school teachers might be improved so that more positive attitude toward, and greater achievement in, mathematics would result. Two methods of teaching mathematics were compared for their efficacy. The first, the experimental treatment, related the material being taught to the elementary school curriculum by means of picture-slide reproductions of selected elementary mathematics textbook pages. The second, the control treatment, was a lecture method of teaching without deliberate relation of the content to the elementary school curriculum.

CONCLUSIONS

The following conclusions were drawn from this study:

1. the use of an in-context method of teaching mathematics produced a greater positive effect on
attitude toward mathematics among prospective elementary school teachers than the use of a lecture method of teaching. However, the difference in effect on attitude between the two treatments was not statistically significant.

2. the use of an in-context method of teaching mathematics produced a greater positive effect on achievement in mathematics among prospective elementary school teachers than the use of a lecture method of teaching. However, the difference in effect upon achievement between the two treatments was not statistically significant.

LIMITATIONS

The preceding research findings should be interpreted with the following limitations of methodology, design and instrument in mind.

Randomization

Because of the inability to randomly sample or to randomly assign the subjects to treatments, it was possible that the experimental and control groups were nonequivalent with respect to some biasing variable which conceivably could have influenced the outcomes of the experiment. One such variable was sex since
both groups were predominantly female. Any attempt to generalize the results of this study should take this variable into consideration.

Another such variable was student class standing. Experimental group responses to questions 4 and 5 of the questionnaire (see page 82) indicated that the course content had been related to the elementary school curriculum; yet, there was a substantial decrease in the number of students who felt that the experimental treatment caused the students to feel a need to learn mathematics. A conjecture explaining the failure of the experimental group to experience this need to learn mathematics was based upon the variable of student class standing. The experimental group was composed predominantly of freshmen and sophomores who had not yet begun their professional education courses. A need might not have been felt for the learning of the basic concepts which these students would later be teaching because the students had neither been exposed to the influence of the professional courses nor were they relatively close to graduation which, for most, would have meant entry to the profession. Conceivably, the same experiment when applied to a student population with a more diverse class composition than the population used in this study, could yield significantly
different results than those determined from this study.

A third variable of possible bias to the study was that of previous mathematical achievement. No evidence of significant differences with respect to this variable was found; however, the possibility of such differences having existed should be recognized as a limitation of this study.

Mixing of Groups

As cited on page 54, there was no feasible way of controlling the effects of students attending Mathematics 105 lectures other than their own. The student responses to the questionnaire (see page 55) indicated minimal contamination of groups. The degree to which the students were truthful in answering this questionnaire must be considered as questionable.

The Achievement Instrument

The achievement instrument used in this study was constructed by the author and was not standardized. Hence, there were items on the test whose item difficulty and item discrimination distributions were low (see Appendix G). This detracted from the quality of the test. Any conclusions rendered in this study
with respect to achievement should take into consideration the limitations of the achievement test.

RECOMMENDATIONS

The recommendations which are put forth in this section have been drawn from both experience in this study and an analysis of its results. These recommendations are of two types: recommendations for future research and recommendations for educational practice.

Recommendations for Future Research

1. The achievement instrument used in this study should be refined so that greater reliability results. Future experiments in Mathematics 105 concerning achievement could then be more reliably interpreted.

2. Replications of this study in both mathematics and other disciplines should be conducted at this and other institutions to test the generalizability of the results and conclusions of this study.

3. Modifications of the experimental treatment should be attempted in other experimental studies. A combined lecture-slide presentation might be attempted.

4. A follow-up study should be conducted to determine the effects, if any, which this experimental
treatment will have upon

a. attitude towards the methods-of-teaching-mathematics course and,

b. achievement in the methods-of-teaching-mathematics course.

Recommendations for Educational Practice

Any generalizations based on the findings of this study must take into account the limitations of the study. With these limitations in mind, it is the experimenter's opinion that, pending further research such as that described above, the following is a valid recommendation for educational practice:

To the extent that relevancy of content to future classroom needs is a desired outcome of the education of prospective elementary school teachers, techniques of teaching similar to those used in the experimental treatment of this study should be an integral part of the methodology used in presenting mathematics to prospective elementary school teachers.
APPENDIXES
APPENDIX A
MATHEMATICS 105
FINAL EXAMINATION - PART I
48 minutes

DIRECTIONS: Mark all answers on the separate answer sheet. Mark only one answer for each question. Please use a pencil and completely erase mistakes. Choose the letter which represents the best choice for the answer to the question.

1. The least common multiple of 24, 18 and 36 is
   a. 108  b. 144  c. 72  d. 12  e. 288

2. The operation a*b = a+2b+ab is defined for all whole numbers. Find 3 * 4.
   a. 22  b. 23  c. 16  d. 19  e. none of these

3. If x represents a whole number for which 3+x=7, we may write 3+x = 3+4. We can then correctly infer that x=4 by use of
   a. intuition.
   b. inductive reasoning.
   c. the commutative law for addition.
   d. the principle of substitution.
   e. the cancellation property of addition.

4. Which one of the following systems of numeration uses the greatest number of different digits?
   a. Roman  d. Base five
   b. Base two  e. Base twelve
   c. Base ten

5. Counting in base two, in which column is there an error?
   a. 1  b. 110  c. 1011  d. 10011  e. no column

6. Which portion of the Venn diagram represents (complement A) ∩ B?
   a. III  d. IV
   b. III and IV  e. II and IV
   c. I, III and IV
7. What is a whole number?
   a. A symbol such as 7.
   b. A point on a number line.
   c. A property common to a set of sets?
   d. A one-to-one correspondence.
   e. A pattern.

8. Which one of the following sets of whole numbers is closed under both addition and multiplication?
   a. The set of odd numbers.
   b. The set of numbers less than 100.
   c. The set consisting of 0 and 1 only.
   d. The set consisting of 0, 1, and 2 only.
   e. The set of even numbers.

9. If A and B are any two finite sets with \( n(A) = a \) and \( n(B) = b \), which of the following must be true?
   a. \( a + b > n(A \cup B) \)
   b. \( a + b = n(A \cup B) \)
   c. \( a + b < n(A \cup B) \)
   d. \( a \times b > n(A \times B) \)
   e. none of these

10. If the set of composite numbers is arranged in increasing order of magnitude, the ninth number in the set is
    a. 9  b. 14  c. 15  d. 16  e. 10

11. Which of the following numerals represents the greatest number?
    a. \( 1111_{\text{two}} \)
    b. \( 102_{\text{three}} \)
    c. \( 23_{\text{four}} \)
    d. \( 21_{\text{five}} \)
    e. All the numerals above represent the same number.

12. Which of the following sets does not have an identity element for addition?
    a. The set of multiples of one.
    b. The set of even numbers.
    c. The set of multiples of fifteen.
    d. The set of divisors of zero.
    e. The set of 7-clock numbers with addition defined to be "clock" addition.
13. A principal use for the least common multiple is the

a. renaming of fractions to express them in simplest form.
b. comparing and contrasting of GCD's with LCM's.
c. renaming of fractions to add or subtract them.
d. giving of practice in writing prime factorizations
e. relating of the concept of sets, set intersections and order in the whole numbers.

14. In tossing a die (singular for dice) what is the probability of obtaining a 3, 4 or 5?

a. one sixth
b. one third
c. one fourth
d. one half
e. two thirds

15. The following questions refer to the following example:

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 1276</td>
<td>51 102</td>
<td>51 256</td>
</tr>
<tr>
<td>102</td>
<td>102</td>
<td>256</td>
</tr>
</tbody>
</table>

In Step 2, 256 is placed where it is to stand for

a. 1276-1020
d. 76-20
b. 2 x 51
e. 1276-102
c. 127-102

16. If a and b are two prime numbers, each greater than 3, which of the following is true?

a. \( a \times b \) is a prime number.
b. \( a - b \) is a prime number.
c. \( a - b \) is a whole number.
d. \( a + b \) is an odd number.
e. \( a \times b \) is an odd number.

17. A student has made the same error in each of the following subtraction examples:

<table>
<thead>
<tr>
<th>58</th>
<th>45</th>
<th>374</th>
<th>517</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9</td>
<td>-9</td>
<td>-96</td>
<td>-226</td>
</tr>
<tr>
<td>59</td>
<td>46</td>
<td>388</td>
<td>391</td>
</tr>
</tbody>
</table>

If he makes the same error in the example below

\[ \begin{array}{r}
284 \\
- \ 65
\end{array} \]

his answer will be

a. 221 b. 229 c. 219 d. 285 e. none of these
18. What is the union of A and B if

$A = \{1,3,9,11\}$ and
$B = \{2,3,4,9,10,11\}$?

a. $\{3,9,11\}$
b. $\{1,2,4,10\}$
c. $\{1,2,3,4,9,10,11\}$
d. $\{(1,2), (3,4), (9,10), (11,11)\}$
e. none of these

19. Students are frequently taught to "invert and multiply" when dividing a fractional number by a non-zero fractional number. The mathematical justification for this algorithm is based upon the

a. inverse and identity properties for multiplication.
b. inverse property for multiplication.
c. identity property for multiplication.
d. distributive property for multiplication.
e. none of these.

20. In a modern positional system with base 15, let our conventional numerals represent the numbers through 9, t represent ten, e represent eleven, w represent twelve, h represent thirteen and f represent fourteen. The base fifteen numeral which is five greater than $e9w$ is

a. $e92$ b. $e9f$ c. $et1$ d. $et0$ e. $et2$ f. $e102$

21. Which of the following symbols does not appear in the written prime factorization of 270?

a. 3 b. 2 c. 5 d. 9 e. none of these

22. The product of 36 and 2 1/2 is the same as 36 multiplied by 2.5. Why do we not indent the partial product of 72 in the second example as is done in the first example?

\[
\begin{array}{c c}
36 & 36 \\
2.5 & 2 1/2 \\
180 & 18 \\
72 & 72 \\
90.0 & 90 \\
\end{array}
\]

a. The factor 2 has a different place value in each example.
b. The factors .5 and 1/2 are not equivalent.
c. The fraction 1/2 does not have place value.
d. The factors .5 and 1/2 have the same place value.
e. 2 1/2 is more precise than 2.5.
23. If \( A \subseteq B \) and \( D \subseteq B \) which of the following must be true?

a. \( A = D \) 

b. \( A \subseteq D \) 

c. \( D \subseteq A \) 

d. \( A \subseteq A \) 

e. none of these

24. An example of an infinite set is

a. the set of natural numbers less than 100. 

b. the set of counting numbers from 1 to 1,000,000. 

c. the set of counting numbers from 56 to 57. 

d. the set of grains of sand on the beaches of the earth. 

e. the set of whole numbers greater than 50.

25. Which of the following operations has no inverse operation?

a. addition \( \text{mod} \ 3 \) 

b. multiplication \( \text{mod} \ 6 \) 

c. multiplication \( \text{mod} \ 5 \) 

d. addition \( \text{mod} \ 4 \) 

e. addition \( \text{mod} \ 6 \)

26. In the problem \( 54 \times 23 \), what is the mathematical explanation of the reason we write the 8 under the 6?

\[
\begin{array}{c}
\phantom{23} \\
54 \\
\times 23 \\
\hline
108 \\
108 \\
\hline
1242
\end{array}
\]

a. We write the product under the factor.

b. We write the product in the tens place because the multiplier is in the ten's place.

c. We move over one place when multiplying by the second figure.

d. We are using a shortcut that works.

e. None of these.

27. If the product of two natural numbers greater than one is odd, their sum is

a. odd and less than their product.

b. even and less than their product.

c. odd and greater than their product.

d. even and greater than their product.

e. either even or odd.

28. Which set is equivalent to \( \{1,3,5,7,9\} \)?

a. \( \{\text{John, Mary, Art, Paul, Alice}\} \)

b. \( \{1,3,5,7,9,11\} \)

c. \( \{1,3,5,7\} \)

d. all of these

e. none of these.
98

29. Suppose we write fractions as ordered pairs. Then \( \frac{3}{4} \) is written as \((3,4)\) and \( \frac{5}{8} \) is written as \((5,8)\). What would be the sum of \((2,5)\) and \((4,15)\)?

a. \((6,20)\)  
b. \((6,15)\)  
c. \((10,15)\)  
d. \((10,5)\)  
e. \((6,75)\)

30. In using the multiplication algorithm to name the product of which property of multiplication is being used?

a. The associative property for multiplication.  
b. The commutative property for multiplication.  
c. The distributive property for multiplication.  
d. Inverse operations.  
e. The identity property for multiplication.

31. Some writers make a distinction between the division operation and the division process defined on the set of whole numbers. This distinction is based upon the idea that

a. the division operation is defined to be the inverse operation of multiplication.  
b. the remainder of the division process must be zero for the process to become an operation.  
c. in order for an operation to be performed, the result of the operation must be unique.  
d. all of the above.  
e. none of the above.

32. If the union of two given sets is the empty set, then the given sets are not

a. finite  
b. equal  
c. equivalent  
d. empty  
e. infinite

33. Given that \( A = \{1,2,3,5\} \) \( B = \{1,2,3,5\} \) \( C = \{2,3,5,1\} \) \( D = \{3,5,1,2\} \)

Which of the following is true?

a. \( B = C \)  
b. \( A = B \)  
c. \( A = D \)  
d. \( A \subset D \)  
e. \( A = B = C = D \)  
f. none of these
34. Which of the following is not true?
   a. A fractional number is an idea.
   b. For each fractional number we have an infinite set of fractions.
   c. If S is the set of fractions for a fractional number and a/b is an element of S, a/b cannot belong to any other such set of fractions.
   d. All of the above.
   e. None of the above.

35. Which one of the following items is false for all values of \( n \)?
   a. \( n \times n = 0 \)
   b. \( 0 \div n = 0 \)
   c. \( 0 \times n = n \)
   d. \( 0 \div n = n \)
   e. \( 0 - n = 0 \)

36. A student who received a test score of 62 thought the grade would look better if he changed the score to a base 8 numeral. After this change, the score appeared as
   a. 76
   b. 54
   c. 64
   d. 75
   e. 706

37. The greatest common factor of 42, 96 and 54 is
   a. 6
   b. 4
   c. 3
   d. 2
   e. none of these

38. In which one of the following pairs of numerals does the numeral 6 represent the same value?
   a. 463_{twelve} and 643_{twelve}
   b. 463_{ten} and 463_{seven}
   c. 643_{seven} and 346_{seven}
   d. 46_{seven} and 46_{ten}
   e. 60_{seven} and 60_{ten}

39. Which of the following subsets of the set of whole numbers contains the least number of elements?
   a. The set of multiples of zero.
   b. The set of divisors of two.
   c. The complement of the set of multiples of zero.
   d. The set of divisors of zero.
   e. The intersection of the set of divisors of zero and the set of multiples of zero.
40. What is \( C \cup D \) if \( C = \{x \mid x < 7\} \) and \( D = \{x \mid 4 + x = 12\} \) where the replacement set for \( x \) is the set of natural numbers?

a. \( \{0, 1, 2, 3, 4, 5, 6, 8\} \)

b. \( \{\} \)

c. \( \{8\} \)

d. \( \{1, 2, 3, 4, 5, 6, 8\} \)

e. \( \{1, 2, 3, 4, 5, 6, 7, 8\} \)

41. In the figure above, \( M \) and \( N \) are numbers located as shown on the number line. Which lettered arrow points to a number that could be the product of \( M \) and \( N \)?


42. \[
\frac{A + \frac{1}{2}}{B + \frac{1}{2}} = C
\]

In order to double the value of the complex fraction above which lettered numeral on the complex fraction should be doubled?


43. If two coins are tossed, what is the probability that they will both land heads or both land tails?

a. \( \frac{1}{4} \)  b. \( \frac{1}{2} \)  c. \( \frac{2}{3} \)  d. \( \frac{1}{16} \)  e. none of these.
Directions: Each statement below expresses a feeling which a particular person has toward mathematics. You are asked to express the extent to which you personally agree or disagree with the opinion stated, on a 5-point scale: SA (Strongly Agree), A (Agree), U (Undecided), D (Disagree), and SD (Strongly Disagree). Fill in the circle at the right indicating the extent of your agreement with the feeling expressed.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I feel at ease with mathematics</td>
<td>SA</td>
<td>A</td>
<td>U</td>
<td>D</td>
</tr>
<tr>
<td>2.</td>
<td>When I hear the word mathematics, I have a distinct feeling of dislike.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>I do not feel sure of myself in mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Mathematics is a subject I feel I can sink my teeth into.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Mathematics makes me feel uncomfortable, uneasy, irritable and impatient.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Mathematics is something which I enjoy doing a great deal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Mathematics is fascinating and fun for me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>I enjoy the challenge of mathematics problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>I feel under a great strain in a mathematics class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I approach mathematics with a feeling of hesitation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Mathematics is stimulating to me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Mathematics is my most dreaded subject.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>I have a definite favorable reaction to mathematics: it's enjoyable.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Working with mathematics is fun.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>It scares me to have to take mathematics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
16. At present, I would rate my general attitude toward math as favorable.

17. Mathematics is very interesting to me.

18. When I approach my mathematics work, I experience a sense of fear of not being able to do it.

19. I have a feeling of insecurity when attempting mathematics.

20. Mathematics is a subject in school which I have liked and enjoyed studying.

21. The feeling I have toward math is a positive feeling.

22. Math makes me feel as though I'm lost in a jungle and can't find my way out.
The following code will be used to designate the elementary mathematics series from which the slides were prepared:

alphabetic letter - designates the series from which page was taken e.g. A - Addison Wesley Co., H - Houghton Mifflin Co., S - L. W. Singer Co.;

Roman numeral - designates the grade level of the series;

Hindu-Arabic numeral - designates the page of the book.

<table>
<thead>
<tr>
<th>Lecture Number</th>
<th>Source</th>
<th>Topic Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H:K-27</td>
<td>geometric patterns</td>
</tr>
<tr>
<td>1</td>
<td>H:II-57</td>
<td>line patterns</td>
</tr>
<tr>
<td>1</td>
<td>A:V-140</td>
<td>number patterns</td>
</tr>
<tr>
<td>2</td>
<td>H:III-1</td>
<td>sets as an idea - collection</td>
</tr>
<tr>
<td>2</td>
<td>H:IV-1</td>
<td>sets as an idea - collection</td>
</tr>
<tr>
<td>2</td>
<td>H:III-2</td>
<td>braces; listing-describing</td>
</tr>
<tr>
<td>2</td>
<td>H:IV-2</td>
<td>capital letters to name sets</td>
</tr>
<tr>
<td>2</td>
<td>S:VI-2</td>
<td>&quot;ε&quot; use</td>
</tr>
<tr>
<td>2</td>
<td>H:IV-3</td>
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# APPENDIX D

## MATHEMATICS 105 CONTENT SUMMARY

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<td>GCD's - LCM's, Order</td>
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APPENDIX E

VALIDATING COMMITTEE

The following people served on the achievement test validating committee.

Benner, Carl V. - Supervisor 7-12, Cincinnati Public Schools; Test author for United States Armed Forces Institute.

Osborne, Alan - Professor of Mathematics Education, The Ohio State University

Riner, John - Professor of Mathematics; Vice-Chairman, Department of Mathematics, The Ohio State University

Trimble, Harold T. - Professor of Mathematics Education, The Ohio State University
APPENDIX F

SOURCE OF TEST ITEMS

The experimenter wishes to acknowledge the following as sources for some of the items used in the Mathematics 105 Achievement Test.

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<tr>
<td>Johnson, D. and Rising, G. (14)</td>
<td>4, 7, 8, 16, 22, 26, 27, 29, 35, 38</td>
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<td>Myers, Sheldon (17)</td>
<td>41, 42</td>
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<td>Romberg, T., and Wilson, J. (50)</td>
<td>15, 17</td>
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<tr>
<td>Trimble, Harold et al. (21)</td>
<td>1, 18, 37</td>
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APPENDIX G

SUMMARY: TEST STATISTICS

TEST STATISTICS DISTRIBUTION

Number of items 43
Mean 28.42
Median 29
Mode 30
Maximum 39
Minimum 11

Standard Deviation 4.35
Skewness -0.49
Kurtosis 0.51
Range 28

RELIABILITY ESTIMATES

K-R 20 0.653  K-R 21 0.502

ITEM ANALYSIS

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Mean item difficulty .339  Mean item discrimination .240
Mathematics 105

Instructor: ______________________ Section: Hour ________________

Name __________________________

1. Would you have preferred that this course be taught completely by lecture without the slide presentation?
   ______ yes _______ no _______ undecided

2. Do you feel that the slide presentation was over done, that is, that the slides were over emphasized or that too much time was spent on them?
   ______ yes _______ no _______ undecided

3. Do you feel that the slide presentation was helpful in learning Mathematics 105?
   ______ yes _______ no _______ undecided

4. Did the slide presentation cause you to feel a need to learn mathematics?
   ______ yes _______ no _______ undecided

5. Did the slide presentation relate the course content to that of the elementary school curriculum?
   ______ yes _______ no _______ undecided

6. Have you enrolled in Mathematics 107?
   ______ yes _______ no

7. Are you planning on taking Mathematics 106?
   ______ yes _______ no _______ undecided

8. At what grade level do you plan to teach?
   ______ k-3 _______ 4-6 _______ undecided _______ other

9. Did the slide presentation influence your choice of grade level to teach?
   ______ yes _______ no _______ undecided

10. Have you attended the two o'clock lectures. If so, please estimate how many times.
    ______ yes _______ no _______ estimate

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APPENDIX I

Mathematics 105

Instructor: ___________________ Section: Hour __________________

1. Have you enrolled in Mathematics 107?
   ______ yes ______ no

2. Are you planning on taking Mathematics 106?
   ______ yes ______ no ______ undecided

3. Have you attended the twelve o'clock lectures. If so, please estimate how many times.
   ______ yes ______ no ______ estimate

4. At what grade level do you plan to teach?
   ______ k-3 ______ 4-6 ______ undecided ______ other

5. Did the lecture presentation influence your choice of grade level to teach?
   ______ yes ______ no ______ undecided

Thank you.
BIBLIOGRAPHY
BOOKS AND PAMPHLETS


UNPUBLISHED DISSERTATIONS


64. Heckman, Maurice A. "The Relative Merits of Two Methodologies for Teaching Verbal Arithmetic Problems to Undergraduate Elementary Education Major." Indiana University, 1962.


75. Williams, Ralph Curtis. "Teacher Preparation in Mathematical Arithmetic." University of Southern California, 1966.