MATHEMATICS FOR PROSPECTIVE ELEMENTARY TEACHERS IN A COMMUNITY COLLEGE: A COMPARISON OF AUDIO-TUTORIAL AND CONVENTIONAL TEACHING MATERIALS AND MODES

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ABSTRACT

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by

Harriett Elenor Emery

The purposes of this study were: (1) to compare the effectiveness of audio-tutorial material and material from a commercial textbook in teaching a semester course in "modern mathematics" to junior college students who are prospective elementary school teachers, and (2) to compare the attitudes of these students toward selected aspects of mathematics.

For the comparison of the effectiveness of the audio-tutorial materials as opposed to the commercial textbook alone, multi-media materials which were appropriate to the junior college level and to the unit and course objectives were designed and prepared for use by the laboratory group. In addition supplementary aids, both teacher-prepared and commercially prepared materials, were incorporated into the laboratory learning situation.

A rating scale was developed as the instrument to assess the student attitudes as measured by their reactions to comments illustrating attitudes toward aspects of

mathematics which are appropriate to the prospective elementary school teacher.

The sample for the study was the students in Mathematics 103 at Schoolcraft College, Livonia, Michigan, in the winter semester of 1970. These seventy-seven students had pre-enrolled when the study was undertaken, and, therefore, one group was randomly selected as the experimental group. At the end of each unit of instruction a test on the unit was administered to the classes. A two-hour final examination concluded the course. The attitudinal survey was administered on the last day of class (part I) and on the examination day (part II).

The analyses for the study were computed on the 3600 computer at Michigan State University Computer Center, using the Missing Data Statistics Program (MDSTAT) and the Finn Multivariate Analysis (FINN). The analysis of covariance, using the Converted Rank in Class scores as the co-variable, was used to correct for the lack of random sampling in the original groups. The Scheffé _Post Hoc_ comparisons were used to locate the significant differences.

On the units where no confounding variables were introduced into the study by the history of events beyond the control of the experimenter, the audio-tutorial method was successful above the conventional groups--either control group or the average of the groups. When the data were controlled for age, the older group was more successful on unit III, Operations and Algorithms.

The control groups had a significant correlation between attitude and achievement, but not the audio-tutorial group. On the question directly related to the audio-tutorial laboratory all groups were in favor of the laboratory. The audio-tutorial group of students (27 out of 27) responded so that the average of their ratings was 4.609 out of a 5.000 possible score; the control groups rated the laboratory 4.063. In the correlation between achievement and attitude toward the laboratory, the control groups had negative correlations indicating the students who are not achieving their goals in the course wanted a source of additional assistance.

Further study and experimentation with this mode of instruction in mathematics courses at the community college level was clearly indicated in the study. A resource laboratory for basic mathematics classes would be a further extension of the basic concept of the audio-tutorial mode of instruction.

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By

Harriett Elenor Emery

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DEDICATION

Mom, Dad, Jane

Who Made It Possible

Renée, Michelle, and Jean-Jean

Who Cooperated, Sometimes

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INTRODUCTION

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Statement of the Problem

The purposes of this study were: (1) to compare the effectiveness of multi-media material (audio-tutorial) and material from a commercial textbook in teaching a semester course in "modern mathematics" to junior college students who are prospective elementary school teachers, and (2) to compare the attitudes of these students toward selected aspects of mathematics.

For the comparison of the effectiveness of the multi-media materials as opposed to the commercial textbook, multi-media materials (slides, audiotapes, posters, and problem work sheets) which were appropriate to the junior college level and to the unit and course objectives were designed and prepared for use by the laboratory group. In addition, supplementary aids, both teacher-prepared and commercially prepared materials, were incorporated into the laboratory learning situation.

For comparison of the student attitudes toward selected aspects of mathematics, a rating scale was developed. This

instrument was used to assess the student attitudes. The measurement scale was the student reaction to comments illustrating attitudes toward aspects of mathematics. The aspects considered were those appropriate to the prospective elementary school teacher, who will be teaching arithmetic.

Importance of the Study

In the last fifteen years the trend in mathematics education has been marked by a definite and very decided increase in the subject matter that is offered at each level in the educational structure. New developments in mathematics at the graduate level have created an increase in the mathematics curricula available to the graduate and to the undergraduate. This increase in mathematics courses has resulted in the addition of material to secondary school mathematics; this addition has, in turn, led to the expansion of the elementary school mathematics curricula.

One result of this consistent trend of moving the subject matter downward in mathematics education has been that (1) the mathematical training of a prospective elementary school teacher, and (2) the attitude of that teacher toward mathematics, have become more important to his successful teaching of mathematics than they ever have been. In 1961 (and again in 1966) the Committee on the Undergraduate Program in Mathematics (CUPM) stated that

> If present trends continue, the better elementary schools may soon be teaching the rudiments of algebra and also some informal geometry. Even in the teaching

> of arithmetic, sound mathematical training is needed because the teacher's understanding affects his views and attitudes; and in the classroom, the views and attitudes of the teacher are crucial. To an undertrained teacher, arithmetic is merely a collection of mechanical processes and is regarded with boredom, or dislike, or even fear. It is not surprising that, in such cases, students react to arithmetic in the same way. Children should be taught arithmetic for meaning and understanding as well as for skills. To teach in this way, a teacher needs to have a kind of training which conveys this understanding and also shows mathematics to be rewarding and worthwhile. The teacher cannot give something which he does not have.[1]

In Michigan the community college concept has been accepted and utilized more successfully each year. In 1964 there were seventeen community colleges in Michigan; in 1969-1970 there were twenty-eight.

Schoolcraft College is a community college located in Livonia, Michigan, and supported by the five communities of Clarenceville, Livonia, Plymouth, Northville, and Garden City. At the time that Schoolcraft College opened its doors (1964), the number of students enrolled in the semester course "mathematics for elementary teachers" and referred to as Mathematics 103 was thirty students. The enrollments in this course increased to ninety students enrolled in three classes of Mathematics 103, each semester in the period from 1968-1970.

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[1]Mathematical Association of America, Recommendations for the Training of Teachers (January, 1961; Committee on the Undergraduate Program in Mathematics, Mathematical Association of America [Berkeley, Calif.: Distributed by the CUPM Central Office, 1961]), p. 5.

All the community colleges in Michigan offer one semester of mathematics for prospective elementary school teachers, with a similar topical outline; some of these colleges have added to their curricula a second course in mathematics for such students, but this course covers algebra or geometry and not a stronger treatment of arithmetic which is the recommendation approved by the senior colleges (not yet implemented).

Two course outlines and a bibliography for a two-semester sequence of courses in "mathematics for elementary teachers," a core curriculum, which had been developed by the subpanel selected by the Southeastern Michigan Community College Mathematics Project (SMCCMP) were accepted and approved at the annual meeting of the Southeastern Michigan Association of Community College Mathematics Instructors on May 11, 1970, at Macomb County Community College in Warren, Michigan. [See Appendix A, for the outlines and bibliography].

The implementation of these outlines in the participating two-year colleges should lead toward a strengthening and unification of the mathematics topics offered to prospective elementary school teachers at these colleges.

A survey of the commercial textbook series that have been adopted by the communities of the College District was made in 1967, including the "modern mathematics topics" and the level of the concepts. Even then, mathematics supervisors in the schools stated that they were anticipating the time when they could legally make a new selection--that would

be "more modern" than the series now in use. [See Appendix B for the texts.]

The need for strong and effective courses in mathematics for elementary school teachers was stressed by the Committee on the Undergraduate Program in Mathematics in its 1969 report:

> Most prospective elementary teachers are not highly motivated toward scientific and mathematical studies and are apt to be less well prepared than many other students. But, if we are to offer to children in the elementary grades a good mathematics program, indeed, if we wish to have the current commercial elementary textbook series well taught, we must manage to persuade these students that mathematics is an important discipline which they can understand. It is imperative that they begin studying the recommended two years of mathematics early, before they have lost too much contact with their earlier training, and in time to strengthen their mathematical backgrounds for other courses in their programs.[1]

The addition of a second course in the mathematics program for the prospective elementary school teacher will be an improvement and a necessary factor in the strengthening of the mathematical training of these students. Before a student can enroll in the second course, he must have passed the first mathematics course. Among these students are many who, though they have succeeded in their other courses and though they showed a potential ability to become satisfactory elementary teachers, could not manage to pass this mathematics course. Some pass it but have a poor attitude, which is due

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[1]Mathematical Association of America, A Transfer Curriculum in Mathematics for Two-Year Colleges, A Report of the Committee on the Undergraduate Program in Mathematics (Berkeley, Calif.: Committee on the Undergraduate Program in Mathematics, Mathematical Association of America, 1969), p. 36.

to their experiences and struggles to drag themselves through the course. Re-enrollment in the course has not been an acceptable solution and certainly is not a satisfactory solution for the student or the instructor. In the educational field where good elementary school teachers are still needed, this loss of potentially successful candidates for elementary school teaching should not be ignored by the community college mathematics instructors and other educators.

At Delta College, a community college near Bay City, Michigan, in the period of 1961-1964 and at Schoolcraft College in the period of 1964-1970 this problem has been apparent to the writer and to the mathematics instructors assigned to teach the course, Mathematics 103. Instructors at the other community colleges and at the four-year colleges of Southeastern Michigan Association of Community College Mathematics Instructors reported that a similar situation existed and even larger enrollments were involved.[1] These instructors expressed concern for their students because many of the topics in the course have been extremely and consistently difficult for the students enrolled in the class. Extending time to be spent on a topic decreases the time available for some other topic. Re-teaching the topic has not increased the achievement sufficiently to justify boring other students.

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[1]Latest reports were made on April 9, 1970, to the Southeastern Michigan Community College Mathematics Project Panel, and on May 11, 1970, at the annual meeting of all members of Southeastern Michigan Association of Community College Mathematics Instructors.

In a course which had no prerequisites, these students were required to learn and demonstrate the principles and concepts of arithmetic and, in addition, set theory and other topics of "modern mathematics." The junior or community college students who are usually enrolled in the classes of mathematics for elementary school teachers are faced with a very difficult obstacle to their chosen vocation; an appreciation of the barrier presented to these students can be fully realized only by the person who is aware of the typical community college student who does enroll in this course.

Definition of Terms

Achievement

This term referred to the scores or grades on the examinations which required responses of the students to items testing the performance of the behavioral objectives for the concepts involved.

Test

This term referred to a teacher-prepared one-hour examination over material and objectives covered in the completed unit of the course.

Final Examination

This term denoted a teacher-prepared two-hour examination over the objectives for the course.

English Test

This term referred to the English Expression Cooperative Test, Form 1 C, from Educational Testing Service. The scores were based on a possible score of 90.

Arithmetic Test

This term referred to a local test on arithmetic computation, developed by the mathematics department to screen for admission to the basic or beginning mathematics class for algebra, business arithmetic, mathematics for elementary teachers, or technical mathematics. The scores were based on a possible score of 45.

Converted Rank in Class

This term referred to the score which was obtained by equating the rank in class at graduation to a standard score on a distribution with a mean of 50 and a standard deviation of 10. This chart is available to qualified personnel from the Educational Testing Service.

Semester

This term referred to sixteen weeks of college work.

Class Time

This term was used to denote the time spent in class work: (1) for the control group the class time for each student was the three one-hour periods each week that the class met, for a total of forty-eight hours; for the experimental group, class time was defined for the individual

student as two one-hour class periods plus the time spent that week in the laboratory, a total of 32 hours plus the total time spent in the laboratory.

Modern Mathematics

This term referred to the material found in set theory, operations in sets, numeration systems, and operations in different base systems. Finite systems also were included.

Attitudinal Scale

This term referred to the departmental survey submitted to the classes at the end of the course for their reactions to statements about attitudes toward aspects of mathematics.

Admissions Battery

This term referred to a selected set of tests which were administered to incoming freshmen at Schoolcraft College. The earlier set had been discarded and a new set was being evaluated. At that time two tests, English and Mathematics, were used. Since the College has an "open door policy," the tests were used for placement purposes.

Objectives

This term was used to mean objectives, stated in behavioral terms, which can be measured for successful completion at the level of the community college students enrolled in the course.

SMCCMP

This term refers to the Southeastern Michigan Community College Mathematics Project--A National Science Foundation study grant, Dr. Arthur F. Coxford, Research Director.

SMACCMI

This term refers to the Southeastern Michigan Association of Community College Mathematics Instructors--organized at Schoolcraft College in 1965, under the leadership of Delbert Piller, Chairman of the Department of Mathematics.

Design of the Study

At Schoolcraft College, a community college in Livonia, Michigan, students who are enrolled in the course, Mathematics 103, "mathematics for elementary teachers," are prospective elementary school teachers on an elementary education program. This course is required for the Associate degree, which is granted by the College, and it (the course) is also required for graduation from the senior institution to which the student may elect to transfer.

From the population of all students who have enrolled in this class, since the College opened in the fall semester of 1964, those who are now enrolled in the course, or those who will be enrolled in the course in the future, the sample chosen to be used in this study was the students enrolled in the course, Mathematics 103, in the winter semester of 1970.

In the fall semester, 1969, the administrative personnel of Schoolcraft College were presented with the design proposed for the study; approval was granted for the study using college facilities and equipment. Arrangements were made for a multi-media laboratory to be set up.

At Schoolcraft College the teaching assignments for the following semester are made very early in the preceding semester. As a result of this policy the writer was the instructor for all three of the classes in Mathematics 103 in the winter of 1970, since the printed schedule had been distributed before final arrangements for the study were completed. Alternate teacher assignments were planned, but they had to be rejected when it became apparent that the elimination of this one difficulty would introduce others which were undesirable. To assign a probationary teacher to teach an audio-tutorial class, without knowing his attitude toward this teaching method, would not be the only problem in the situation. Would the teacher spend the designated hours so that he was available in the laboratory? Would he make the audio-tape recordings so that his students could identify with him as they listened and worked? Would he be able to understand these students and their special needs? What would his attitude toward the class be if he should resent the change of assignment?

The judgment was made to let the enrollments proceed just as any other regular semester, with no undue attention given to these classes.

By random sample the ten o'clock class was designated to be the experimental group and the eight and nine o'clock classes became the control group. (Selection was made before registration began.)

The control classes met three days a week for the usual class hour, which is informal lecture, discussion, question and answer, or test session. The experimental class met two days a week for the usual informal lecture, discussion, or test session. The third class hour was replaced by an audio-tutorial laboratory.

The Hypotheses

There will be a definite increase in achievement as a result of the audio-tutorial method and materials. There will also be an improvement of the student attitude toward mathematics as a result of the audio-tutorial mode of instruction. In order to test the significance of these hypotheses, the following null hypotheses were used for statistical analysis:

1. There are no significant differences between the effectiveness of the multi-media materials and the selected materials from a commercial textbook.

2. There are no significant differences in achievement under the two modes of instruction, when the older students are compared with the younger in each group.

3. There are no significant differences in achievement under the two modes of instruction, when the groups

are compared on the basis of entering college immediately upon graduation or after a lapse of time.

4. There are no significant differences in achievement under the two modes of instruction, when the groups are compared on the basis of attendance at an urban or a suburban high school.

5. There are no significant differences in achievement under the two modes of instruction, when the groups are compared on the basis of attendance at a private or a public high school.

6. There are no significant differences in attitudes, the total attitude, or the eight categories, under the two modes of instruction.

7. There are no significant differences in the attitudes, the total or the eight categories, under the twc modes of instruction when the groups are compared on the basis of (a) age, (b) lapse/direct from high school, (c) private/ public high school, and (d) urban/suburban high school.

Assumptions and Limitations of the Study

Assumptions

1. The sample will not differ significantly from the population. Special mention should be made of the motivation problems involved in teaching this course. The students who are enrolled in this course have already acquired the standards, aims, interests, goals, and reinforcement and reward systems of American high school graduates of average ability

(especially those of the high schools in the immediate vicinity). In their previous studies of mathematics, which vary considerably, these students have developed attitudes toward mathematics which range from tentative hope of success to a feeling of uncertainty, dislike, distrust, and sometimes even dread. The more mature students differ from the younger in that (1) they take more time to learn the same amount of material, (2) they persevere longer and strive harder, (3) they set higher standards for themselves, both on the individual assignments and during the entire course, (4) they want to learn as much as they can so that they will be better prepared to teach arithmetic, (5) they develop much more tension, anxiety, or frustration than the younger students do, and (6) they usually have more and sometimes pressing family responsibilities or emergencies.

2. At the time that the experiment was conducted the classes covered the following material: (a) importance of mathematics in modern living; (b) patterns; (c) sets--notation, universal set, null set, element of a set, union of sets, intersection of sets, subsets, proper subsets, cardinality of a set, finite sets, infinite sets, whole numbers, natural numbers, even numbers, odd numbers, multiples, primes, bases, constants, variables, Cartesian products, ordered pairs, modulus; (d) whole numbers with bases that = 10 and bases that ≠ 10; (e) changing bases; (f) operations with whole numbers in various base systems; (g) algorithms for four

fundamental operations in whole numbers; and (h) problem-solving in arithmetic.

3. The sample, which did not differ significantly from the population, will not differ significantly from similar classes in other community colleges.

4. It was assumed that the examination materials were kept secure and that students had no opportunity to practice the questions on the tests. (Review sheets were given to each student a week before the test period.) It was further assumed that the tests were given at about the same time, that the directions for testing were followed in all groups, and that adequate test conditions were maintained.

5. It was assumed that the students were frank and sincere in their responses on the survey, thereby trusting the writer to follow the procedure as described. [See Appendix C for Attitude Scale.]

Delimitations

The study was designed to evaluate the effectiveness of the audio-tutorial method of teaching when used in a mathematics class, Mathematics 103. It was not designed to develop materials for teaching the course, an incidental result of the study. It was not designed to demonstrate a need for a second course to follow this course. The decisions on the subject matter to be included in the course and the course which should follow had already been made when this study was carried out.

The topics and concepts included in the course were the same for both groups. All students enrolled in Mathematics 103 at Schoolcraft College in the winter semester, 1970, were included in the study. Students who dropped the course were later excluded from the study.

Limitations

The study was limited by the size of the sample, the number of students enrolled in Mathematics 103 (N=77). A further limitation was the number of students who graduated from Detroit schools where rank in class was not computed. Rank in class was used as the co-variable in the analysis of the data.

Related Studies

A review of studies, which included approximately 70 reports submitted at the Audio-Tutorial System Conference at Purdue University on October 20-21, 1969, revealed that the method was used most frequently at the college level, two-year and four-year colleges (60 reports). The reports were in these areas: biology (20), botany (11), chemistry (1), physics (2), geography (2), earth or soil science (2), nursing (3), medicine (1), foods (2), social studies (5), electronics (2), and others; none were in mathematics or mathematics education.[1]

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[1]See Appendix D, for Audio-Tutorial Method in Biology at Schoolcraft College.

The reports mentioned above were descriptions of the results of adoptions and adaptations of the audio-tutorial method to a class, a department, or to a division of the school involved. None demonstrated a controlled study in the use of audio-tutorial method; even Husband and Postlethwait have stated that a small experiment in 1962 showed no improvement in achievement but did show a definite saving of student time in learning the concepts of the course (freshman botany).[1] This experiment used audio-tapes for the lectures that were to be delivered the following week. The tapes were on reserve in the library for student use. From this beginning study at Purdue University, with a sample of 36 students in one class, the audio-tutorial method was declared a success and was improved in the years that followed, without any further testing.

Fitzgerald has stated that no controlled experiments have been done to evaluate the effect or achievement obtained by including the two-hour laboratory in the mathematics for elementary teachers course at Michigan State University.[2]

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[1] D. D. Husband and S. N. Postlethwait, "The Concept of Audio-Tutorial Teaching" (unpublished Ph.D. dissertation, Dept. of Biological Science, Purdue University), p. 25.

[2] Interview with William Fitzgerald, Professor, Michigan State University, June, 1969, and address by William Fitzgerald at Michigan State University on November 8, 1969, for Southeastern Michigan Association of Community College Mathematics Instructors.

Boonstra found that there was no significant transfer of these laboratory materials into the teaching of classes by these prospective elementary teachers.[1]

A study of the volume, Research in Mathematics Education, from the National Council of Teachers of Mathematics revealed no studies of mathematics that would involve (1) prospective elementary school teachers, (2) mathematics, and (3) the audio-tutorial method. Studies on prospective elementary teachers were: (1) developing materials, (2) contrasting textbooks with lectures, (3) closed circuit television, (4) types of lectures, (5) types of exercises with concepts, (6) developing additional materials and courses.[2]

Succeeding Chapters

In Chapter II the background of the problem has provided a description of the evolving situation and a review of the literature has given an evaluation of completed studies and those proposed in the area of this study, as a basis for the completion of this experiment. In Chapter III is the problem described in detail. Included are the procedure and the method

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[1]Paul Henry Boonstra, "A Pilot Project for the Investigation of the Effects of a Mathematics Laboratory Experience: A Case Study" (unpublished Ph.D. dissertation, Michigan State University, 1970).

[2]Boyd Holtan, "Some Ongoing Research and Suggested Research Problems in Mathematics Education," Research in Mathematics Education, ed. Joseph M. Scandura (Washington, D.C.: National Council of Teachers of Mathematics, 1967), pp. 109-113.

of collection of the data. Chapter IV is a description of the analysis and interpretation of the data. In Chapter V are conclusions, results, and recommendations for further research.

CHAPTER II

BACKGROUND OF THE PROBLEM
AND REVIEW OF THE LITERATURE

Introduction

The background of the historical development of the problem was presented as a perspective for the current study; the background of research and theory was the foundation for the study.

For a study of the effectiveness of the audio-tutorial mode of teaching modern mathematics to community college students who are prospective elementary teachers a survey of the current literature reporting research studies was conducted. In order to provide a clear perspective for the audio-tutorial study the literature was reviewed and classified in these categories: (1) prospective or in-service teachers of elementary school mathematics, (2) junior college students, (3) attitudes toward mathematics, and (4) audio-tutorial mode of teaching.

The Problem

Historical Background

In the 1950's mathematics instructors meeting at the annual conventions of the National Council of Teachers of

Mathematics and the Michigan Council of Teachers of Mathematics were wont, during their late evening informal sessions, to gather in groups and to compare their experiences in teaching their current classes. The college instructors ascribed their teaching problems to failure at the high school level; and the high school instructors, in turn, attributed their problems to failure of the teachers at the elementary level.[1]

In the late 1950's two factors began to evolve that have been important in the development of the present-day (current) elementary school mathematics curricula. The first of these factors was "modern mathematics." As early as 1957 instructors who utilized materials which had been written in 1953 and 1955 included these "modern topics in mathematics" in their graduate level mathematics courses.[2]

In 1959 these "modern topics" were recommended for the secondary school curricula for

> the new subject matter and point of view are to be intertwined with much that is old and valuable in both subject matter and points of view, [and in this manner] we arrive at the conclusion that: (1) "Modern

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[1]In the 1950's the number of elementary school teachers who were interested in teaching mathematics and were attending these annual meetings was very small in relation to the number of college and high school teachers in attendance.

[2]Phillip S. Jones, who is recognized nationally as an outstanding teacher, offered such a course at the University of Michigan, using the following "modern mathematics topics": (1) E. R. Stabler, An Introduction to Mathematical Thought (Cambridge, Massachusetts: Addison-Wesley Publishing Company, 1953), (2) W. L. Duren, Jr., and D. R. Morrison, Universal Mathematics, Part II, Structures in Sets (Preliminary Ed.; New Orleans, Louisiana: Tulane University Book Store, 1955), and (3) as a current events topic: a critical review of a proposed chapter of the then pending twenty-fourth yearbook for the National Council of the Teachers of Mathematics.

> mathematics" does not mean a total abandonment of all--or even much--of what has been taught in the past.[1]

Agreement with this judgment was expressed by the School Mathematics Study Group in a newsletter of March, 1961, detailing subgroup plans as follows:

> II. Mathematics for Grades 9 through 12.
>
> This project is devoted to the production of a series of sample textbooks for grades 9 through 12. For the most part the topics discussed in these textbooks do not differ markedly from those included in the present-day high school courses for these grades. However, the organization and presentation of these topics is different. Important mathematical skills and facts are stressed, but equal attention is paid to the basic concepts and mathematical structures which give meaning to these skills and provide a logical framework for these facts.[2]

From the high school and then into the elementary school, the need for a stronger mathematics program at the elementary school level was proposed in the same School Mathematics Study Group newsletter:

> In this project SMSG will undertake a critical study of the elementary school mathematics curriculum from the point of view of: increased emphasis on concepts and mathematical principles; the grade placement of topics in arithmetic; the introduction of new topics, particularly from geometry; and supplementary topics for the better students, for example from number theory.[3]

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[1]Phillip S. Jones, "The Mathematics Teacher's Dilemma," *The University of Michigan School of Education Bulletin*, XXX (January, 1959), pp. 65-72, reprinted in *Notes for the Mathematics Teacher*, Number 1 (New York: World Book Company), p. 4.

[2]School Mathematics Study Group, *Newsletter Number 6* (New Haven, Connecticut: Yale University, March, 1961), p. 5.

[3]*Ibid.*, pp. 7-8.

This need, recognized nationally, for a stronger and richer program in mathematics had been projected downward from the college level to the secondary school level, to the elementary school level, and then was brought back to the college level and into the teacher training programs. In 1961, the Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics announced its recommendations for

> an undergraduate mathematics curriculum for <u>all</u> students preparing to teach at what the Panel described as Level I: teachers confronted with the problem of presenting elements of arithmetic and the associated material commonly taught in grades K-6.[1]

During the time that the first factor, "modern mathematics," was gaining support, the second factor, "the mathematics curriculum for K-12," was starting to develop. This theme, which had been growing among educational groups, gained national recognition in 1959 with the publication of the Twenty-fourth Yearbook of the National Council of the Teachers of Mathematics, <u>The Growth of Mathematical Ideas, K-12</u>. Further recognition for the theme was forthcoming; in 1960 the Michigan Education Association used this K-12 theme for all regional meetings--especially for the subject matter conferences for each region. The theme for the one-day

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[1]Mathematical Association of America, <u>Course Guides for the Training of Teachers of Elementary School Mathematics</u> (Revised, 1968; A Report of the Panel on Teacher Training, Committee on the Undergraduate Program in Mathematics, Mathematical Association of America [Berkeley, Calif.: Distributed by the CUPM Central Office, 1968]), p. 1.

program was the creation and communication of common goals and problems in mathematics for all grades, K-12.

At that time (1960) the National Council of Teachers of Mathematics and the Michigan Council of Teachers of Mathematics began to invite and to urge the attendance of elementary school teachers at their meetings and their annual conventions. Each year these associations have scheduled meetings (sessions) so that they were led by elementary school teachers and have structured general sessions so that they were directed toward the interests and needs of these teachers. As a result, each year the number of elementary teachers attending these conferences has increased over the number that attended in previous years.[1]

Until 1969 the interest in elementary teacher training programs was directed toward the students enrolled in the four-year college or university. Earlier reports of the Panel on Teacher Training gave recommendations for a strong program of two years of additional mathematics in the training of elementary school teachers. In 1969 the Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics recommended that "all two-year colleges offer the year course in the number system, Mathematics NS. It should be emphasized that, in the view of the Panel on

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[1]In 1970 the National Council of Teachers of Mathematics voted a dues schedule of two dollars for elementary teachers and four dollars for all other educators.

Teacher Training, this is minimal training for the elementary school teacher."[1]

During the school year of 1969-70 a panel or committee from the Southeastern Michigan Association of Community College Mathematics Instructors (SMACCMI) has met monthly, under a grant from the College Science Improvement Program (COSIP) of the National Science Foundation (NSF) to consider the transfer curricula in mathematics from the community colleges, including mathematics for elementary school teachers.[2] In September, 1969, at the invitation of the Panel on the Transfer Curricula of the Southeastern Michigan Association of Community College Mathematics Instructors, the Committee on the Undergraduate Program in Mathematics sponsored a symposium, at an invitational conference, for representatives from the mathematics departments of the institutions that are members of the Association. The purpose of this conference was consideration of the new recommendations by the Panel on Teacher Training (CUPM) for the reactions of the conferees to these recommendations. At the session devoted to mathematics for elementary

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[1] Mathematical Association of America, A Transfer Curriculum . . . Two-Year Colleges, p. 36.

[2] The two-year colleges are: Delta College (Bay City), Flint Community Junior College, Henry Ford Community College, Highland Park College, Jackson Community College, Lansing Community College, Macomb County Community College, Monroe County Community College, Oakland Community College, Schoolcraft College (Livonia), St. Clair County Community College, and Washtenaw Community College; and the four-year institutions are: Central Michigan University, Eastern Michigan University, Michigan State University, Northern Michigan University, Oakland University (Rochester), the University of Michigan, and Wayne State University.

school teachers, all conference participants accepted the recommendations as valid. It was pointed out that some two-year colleges offer two semesters of mathematics; only one of these is devoted to study of the number system (arithmetic). The decision to carry the recommendation to the curriculum committees of the two-year colleges involved was expressed by the members of this session. The attention of all conferees was called to the following paragraph:

> A subsequent survey by the Panel shows that the amount of mathematics required of prospective elementary school teachers had approximately doubled in the period from 1961-1966. In spite of these gains, the full implementation of the recommendation has not yet been achieved. There are many reasons for this outside the control of the mathematics departments, primarily the tremendous demands on the time of the prospective elementary school teacher.[1]

Background of Research and Theory

There is an ever increasing interest in the development and use of audio-tutorial, or multi-media, instruction as a method of teaching. The advantages claimed for programmed instruction, whether by machine or textbook, may apply equally well to this method of instruction. These advantages are: individualized instruction, behavioral objectives, sequencing, pacing, feedback, constructive evaluation and improvement. To these advantages can be added the variety of media that may be utilized to involve the senses of sight, hearing, and touch; the senses of smell

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[1]Mathematical Association of America, loc. cit., p. 36.

and taste, where appropriate to the objectives, could be used effectively.

Most authorities include the following as the assets to be gained with the use of the audio-tutorial method:

1. the selection of the laboratory-learning period by the individual student.
2. the variety of learning activities included in each lesson.
3. the student's active participation in the learning situation.
4. the interaction of student and qualified instructor, at the time that the student feels the need for assistance.
5. the student's progress and achievement in each lesson is at his own pace or rate and is limited by his decision.

Postlethwait said that with this method the student has the advantage of the following ingredients for an educational program: (1) repetition, (2) concentration, (3) association, (4) unit steps, (5) a communication vehicle appropriate to the objective, (6) a multiplicity of approaches, and (7) integrated experiences.[1]

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[1] S. N. Postlethwait, J. D. Novak, and H. T. Murray, Jr., The Audio-Tutorial Approach to Learning, Through Independent Study and Integrated Experiences (2nd. ed.; Minneapolis, Minnesota: Burgess Publishing Company, 1969), pp. 3-4.

At the 1969 Audio-Tutorial Systems Conference Postlethwait stated that he felt the method of teaching was successful, but that he had not conducted research to substantiate his conviction.

At the same conference Novak made the following points on research that could be applied to the audio-tutorial technique:

1. The learning theories of David Ausubel provide "a very adequate base for designing and interpreting research studies, especially those involving individualized instruction such as in audio-tutorial teaching."[1]
2. "You may wish to explore theoretical suggestions by Bruner, Gagné, Piaget, Smith and Smith, Skinner, or other psychologists but in the judgment of my graduate students Ausubel presents the most heuristic theory for proceeding in the design and analysis of research."[2]
3. "Distinguish rote reception learning from meaningful reception learning (explaining Ausubel); and there is need for subsumers (functional concepts)

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[1]Joseph D. Novak, Relevant Research on Audio-Tutorial Methods, A Paper for the Audio-Tutorial Systems Conference at Purdue University (West Lafayette, Indiana: Purdue University, October 20, 1969), p. 1.

[2]Ibid.

before meaningful learning, and advance organizers before the subsumers."[1]

Galanter listed these advantages for programmed instruction: "(1) all the advantages of a private tutor; (2) increase in the overall time efficiency of the learning process . . . 3 to 1; and (3) frees the teacher for creative and uniquely human tasks which only the teacher can perform."[2] That there is a need for research in the use of programmed instruction is evidenced by professional literature, which points out this need explicitly. In a joint committee report on programmed learning materials the committee recommended that (1) the effectiveness of a self-instructional program be assessed by finding out what students actually learn and remember from the program, and (2) active experimentation with self-instructional materials and devices in school systems is to be encouraged prior to large scale adoption.[3]

As Dr. Scannell said, "I believe that the state of the art (or science) called teaching elementary school mathematics can be advanced even if original, ice-breaking studies

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[1] Ibid.

[2] Eugene Galanter, "The Mechanization of Learning," NEA Journal, (November, 1961), p. 18.

[3] "A Statement on Self-Instructional Materials and Devices by a Joint Committee of the American Educational Research Association (NEA), the Department of Audio-visual Instruction (NEA), and the American Psychological Association," NEA Journal, (November, 1961), p. 19.

are conducted in limited settings, with limited generality."[1] He also added that relevant factors must be described in the fullest.

Review of the Literature

Elementary School Teachers

In-Service Teachers

In 1967 Suydam reported the research studies on elementary school mathematics that had been published as journal articles, during the period from 1900 to 1965, as a part of her dissertation.[2] Of these articles 158 were published in The Arithmetic Teacher; 132 in The Elementary School Journal; 36 in The Mathematics Teacher; and 30 in The Journal of Experimental Education. Other articles were published in journals, but only a few in any one of the journals. Suydam noted that The Arithmetic Teacher, although in publication only since 1954, published one fifth of all the reports.[3]

In 1970 Riedesel summarized the recent research in elementary school mathematics. The report covered three categories of research: (1) approaches to content, (2)

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[1] Dale P. Scannell, "Obtaining Valid Research in Elementary School Mathematics," The Arithmetic Teacher, XVI (April, 1969), p. 295.

[2] Marilyn N. Suydam, "The Status of Research on Elementary School Mathematics," Arithmetic Teacher, XIV (December, 1967), pp. 684-689.

[3] Ibid., p. 685.

approaches to teaching, and (3) materials.[1] A bibliography, with entries that were published from September, 1944, to July, 1968, was included at the end of his article. These articles summarized by Riedesel reported research studies in the elementary school, with in-service teachers, and with elementary school pupils.

In this category, a comparison of the dissertation abstracts and of the articles in the professional journals, including the new Journal for Research in Mathematics Education,[2] and the first issue of The Two-Year College Mathematics Journal,[3] revealed that studies completed before 1969 (dissertations) are usually found as articles in the professional journals.

Ginther, Gibney, and Pigge have studied the "mathematical understanding" of elementary school teachers classified according to (1) the size of community in which they taught, (2) the size of the community where they were graduated from high school, (3) the subject they preferred to teach, and (4) the

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[1]C. Alan Riedesel, "Recent Research Contributions to Elementary School Mathematics," Arithmetic Teacher, XVII (March, 1970), pp. 245-252.

[2]National Council of Teachers of Mathematics, Journal for Research in Mathematics Education, I (Washington, D.C.: National Council of Teachers of Mathematics, 1970).

[3]Mathematical Association of America, The Two-Year College Mathematics Journal, I (Boston, Massachusetts: Prindle, Weber and Schmidt, Incorporated, 1970).

subject they preferred not to teach.[1] The summary of the analyses pointed out these results: (1) the mean score for teachers who graduated from medium-city high schools was significantly more than the mean score for the teachers from large-city high schools; (2) teachers who most preferred to teach mathematics did significantly better on the test than those who preferred to teach language arts, science, or social science; and (3) the teachers who least preferred teaching mathematics did significantly poorer on the test than those teachers who least liked to teach language arts, science, or social science.[2]

The studies referred to previously were devised to involve in-service elementary school teachers, as did the studies conducted by Clarkson and by Hunkler, rather than studies to involve pre-service or prospective elementary school teachers. Clarkson recommended summer institutes to increase

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[1] Thomas C. Gibney, John L. Ginther, and Fred L. Pigge, "What Influences the Mathematical Understanding of Elementary-School Teachers?" The Elementary School Journal, LXX (April, 1970), p. 368.

[2] This study supports the administrative decision of the elementary school principal who, by an informal arrangement with the teachers, allows the elementary school teacher who prefers to teach mathematics to do all or most of the arithmetic teaching in the school. This comment was made in an oral report to the Subpanel on Elementary School Mathematics at the Southeastern Michigan Association of Community College Mathematics Instructors Annual Conference on May 11, 1970, at Macomb County Community College, Warren, Michigan.

the effectiveness of in-service elementary school teachers.[1] Hunkler drew the conclusions that (1) one course in college mathematics did not significantly improve the achievement of the pupils, and (2) that two or more courses had some positive effect on the achievement of their pupils, a verification of the recommendation for a full year of mathematics (Committee on the Undergraduate Program in Mathematics).[2]

These studies of research on in-service elementary school teachers were of significance as a background for the review of research that is concerned with the pre-service elementary school teacher.

Pre-service and In-service Teachers

In a recent report of research Gibney, Ginther, and Pigge compared the "mathematical understandings" of pre-service and in-service elementary school teachers.[3] The sample consisted of (1) pre-service teachers, the students who were enrolled in elementary education courses and who had

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[1]Donald Robert Clarkson, "The Effect of An In-Service Summer Institute on Mathematical Skills, Understandings, and Attitude Toward Mathematics of Elementary School Teachers," (University of Connecticut, 1968), Dissertation Abstracts, XXIX, 9 (March, 1969), p. 3019-A.

[2]Richard Frederick Hunkler, "Achievement of Sixth-Grade Pupils in Modern Mathematics as Related to Their Teachers' Mathematics Preparation," (Texas A & M University, 1968), Dissertation Abstracts, XXIX, 11 (May, 1969), p. 3897-A.

[3]Thomas C. Gibney, John L. Ginther, and Fred L. Pigge, "The Mathematical Understandings of Preservice and In-service Teachers," Arithmetic Teacher, XVII (February, 1970), pp. 155-162.

completed at least one three semester-hour course in mathematics, and (2) the in-service teachers who were enrolled in undergraduate or graduate mathematics education courses. The sample for the study was taken during 1968 and 1969 at Bowling Green State University, the University of Toledo, and Eastern Michigan University.[1] The assumption was made that the sample had the characteristics of the population from which it was drawn, the population being the individuals who fit the category descriptions and who reside in the geographic location from which the three universities receive their students. The extension of the study is made to students enrolled in the courses described and at the universities, all students who have been enrolled or are enrolled.

A test of selected modern mathematics topics in seven areas was administered to the subjects of the study. In Part I, the findings were:

1. Pre-service teachers had a higher mean score in each of the seven areas than did the in-service teachers, with five of these being significant, that is, (a) total, (b) geometry, (c) number theory, (d) structural properties, and (e) sets. These are listed as "modern," as opposed to fractions and operations which were regarded as traditional.

2. The mean score of the pre-service teachers was significantly higher than the mean score of each in-service group.

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[1]_Ibid._, p. 156.

3. No significant differences were found among the mean scores of the four groups of in-service teachers who have taught 0-2, 3-5, 6-10, or more than 10 years.

4. The in-service teachers who had taught more than 10 years had the lowest mean score and the largest standard deviation.

The test used for this study had a .80 reliability, as computed by the Kuder-Richardson Formula 21. The data for this study were analyzed by using the means, the standard deviations, one-way analyses of variance, t-ratios of means, and a "t" ex post facto comparison for all possible pairs of means, and the Scheffé method, wherever appropriate.[1]

The conclusion and summary of the study stated that

> the two groups of students are sufficiently different to warrant different treatments in the mathematics education courses for these groups. The preservice teachers should have a course which is designed and organized to meet their special needs and abilities.[2]

In Part II, the investigators compared the data on the basis of the grade level either to be taught or being taught. Significant differences, as indicated in parentheses, occurred for the pre-service teachers in the groups: kindergarten (1); first and second grades (4); third and fourth grades (5); fifth and sixth grades (1); and seventh and eighth grades (none).

The results reported were:

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[1] Ibid., p. 156 and 158.

[2] Ibid., p. 158.

1. Significant mean differences existed between pre-service and in-service teachers in favor of the pre-service teachers in grades 1 and 2, and grades 3 and 4, and not in kindergarten, grades 5 and 6, and not in grades 7 and 8.

2. The pre-service teachers' scores, by the chosen grade level, did not yield significant mean differences in mathematical understandings in any levels, from the kindergarten through the eighth grade.

3. A significant trend was found in in-service teachers scores in relation to the grade level taught--the higher the grade level taught, the higher the score.[1]

The previous study by Gibney, Ginther and Pigge had, as one part of the sample, students who (1) completed at least one mathematics course on the number system and (2) were enrolled in elementary education courses (no previous teaching experience). Pigge and Brune noted in their research, which involved students enrolled in a course on the methods of teaching mathematics, that no significant difference in achievements of the groups resulted from their analysis of the data.[2] They did, however, express a professional opinion that reviewing the teachers' manuals and the pupils' textbooks for elementary arithmetic did give that student group (manuals)

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[1] Ibid., p. 162.

[2] Fred Pigge and Irvin H. Brune, "Lectures Versus Manuals in the Education of Elementary Teachers," Arithmetic Teacher, XVI (January, 1969), pp. 48-52.

the advantage of having worked with "the tools of their future trade."

The research articles, abstracts, and summaries described above have involved elementary school mathematics teaching, but none have applied to the student on an elementary education program and enrolled in his first (and required) mathematics course, which may be his only mathematics course. At the community college this means within the first two years of college credits and excludes the use of "methods" materials in the course. The question that then arises is, "What research has been done involving the community college or junior college?"

Community College Students

In a study at the University Community and Technical College of the University of Toledo, Morgan developed an equation for predicting success in college mathematics classes, for the students enrolling at the college. Since the college administered the Cooperative Mathematics Test for Algebra II for purposes of student placement in the mathematics sequence ("open door" policy of admission to community colleges), Morgan computed a discriminant equation which is reported to be accurate in 90 percent of its predictions when using the following predictor variables: "(1) score on a cooperative mathematics test; (2) years of high school mathematics; (3) mean grade in high school mathematics, and (4) age in months beyond the seventeenth birthday."[1]

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[1]William P. Morgan, "Prediction of Success in Junior College Mathematics," Mathematics Teacher, LXIII (March, 1970), p. 261.

Although the students in the sample of Morgan's research are the same age as the subjects in this project, the students at the University of Toledo may differ in other characteristics; for instance, they are probably more mathematically trained and oriented than the subjects of this investigation, as students who are to be successful on an engineering technology program need to be.

In another study of junior college students Meyer studied the junior college student to evaluate the junior college as a means for status enhancement.[1] The summary of his report included:

1. The low status, high skill, mobile group is the only group of the six that did use the community college for status enhancement.

2. Skill is believed to be the best single indicator of program preference and dropout.

The major recommendation from the study included the admonition that consideration of all three factors be a part of any study of behavior patterns of junior college students.[2]

The research articles on community colleges, and on community college mathematics in particular, that are published in the current literature are scarce and hard to find. Much

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[1]John David Meyer, "Junior College Students: Status Inconsistency," (Stanford University, 1968), Dissertation Abstracts, XXIX, 11 (May, 1969), p. 3776-A.

[2]Ibid.

needs to be learned of the community colleges and the students at these colleges; for the increase in the number and size of the community colleges in Michigan alone shows the importance of gathering the data for decision-making at this level of education. How much of the research on four-year college students is applicable to the community college student, and especially to the students who are on transfer curricula, curricula which parallel the programs offered at the four-year schools? Will achievement of these two groups of students be equivalent? Will their attitudes be similar?

Attitudes Toward Mathematics

Neale has summarized some of the research on the attitudes and mathematics.[1] He reported on the International Study of Achievement in Mathematics (Husen, 1967):

> The implication is clear. If certain attitudes are important objectives of mathematics instruction, then such attitudes must be given deliberate and separate attention, both in the development of mathematics curricula and in curriculum evaluation. Likewise, teachers need to give systematic attention to classroom activities that develop desirable attitudes.[2]

Neale presented sample items from the Dutton (1956) and the Aiken (1963) versions of a like-dislike and approach-avoidance scale to measure attitude toward learning mathematics.

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[1]David C. Neale, "The Role of Attitudes in Learning Mathematics," Arithmetic Teacher, XVI (December, 1969), pp. 631-640.

[2]Ibid., p. 632.

The sample items he included from the International Study[1] also included items on perceived success in mathematics and aspirations to work in math-related occupations.

Sample items illustrating a different approach, a semantic differential scale to measure attitude toward learning mathematics, from research by Anttonen in 1967, are also included in Neale's article.[2] On Anttonen's scale the subject must record his attitude toward mathematics on a nine-point range between bipolar selections: (1) from distasteful to enjoyable; (2) from new to old; (3) from sharp to dull; (4) from weak to strong, or (5) from valuable to worthless.

Neale classified the attitude toward learning mathematics as having a special status among attitudinal objectives in mathematics and he recommended that Mager's clear and engaging statement on this belief would assist the instructor of mathematics.[3] Neale stated two results of his study of the articles on attitudes: (1) students develop an increasingly unfavorable attitude toward mathematics as they go through school and (2) at present these attitudes play only a slight part in learning mathematics. These results are from studies in which the subjects were elementary and secondary school students.

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[1]Ibid., p. 633.

[2]Ibid.

[3]Robert F. Mager, Developing Attitude Toward Learning (Palo Alto, California: Fearon Publishers, 1968).

Of interest here is the observation from the correlation and multiple regression studies for the proportion of mathematics achievement that is attributable to intelligence, to prior achievement, and to attitude toward mathematics. With a variation or R^2 of .776, the correlation for achievement and attitude is .35; the correlation of achievement with I. Q. and prior achievement, jointly, is .386, or 38.6% of variation in mathematics achievement.

Neale discussed attitudes in children and attitudes toward learning which are interesting to an elementary teacher but are not as effective for students who are in community colleges, except as an explanation of the attitudes of these students as the result of their experiences in elementary and secondary school. However, Neale closed his article with an intriguing argument. After supporting the suggestion that students decide what should and shall be done in schools they attend, on the assumption that the principal motivation for learning is intrinsic interest, he then pointed out that commercial television has shown that reliance on intrinsic interest would not be likely to result in education, as he defined that term. He asked, rhetorically, "Who would go to work daily without pay and solely for the joy that comes from working?"

In conclusion he expressed this value judgment:

> We are mistaken if we create in beginning teachers the impression that learning mathematics must spring from some unquenchable thirst for mathematical knowledge. We are better off to tell the truth--that

> children learn mathematics for a combination of reasons, which include a desire to do their duty, be good children, and gain adult approval.
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> . . . .
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> The school should be a place where that work goes forward, where necessary tasks are made attractive and rewarding, where every motivation children and adults have is used to encourage learning. I applaud the efforts of mathematics educators who seek to appeal to curiosity and fun. I wish they would in addition work to change the institutions in which learning takes place, for I believe that such change attacks the problem of motivation for learning in a more fundamental way.[1]

Suydam and Riedesel have collected and listed the applicable generalized research findings which the classroom mathematics teacher may employ and test. Selection of sample items are:

Individualizing instruction improves immediate achievement, retention, and transfer.

Modern mathematics programs tend to produce better reasoning and retention but computational skills are not always better than in traditional programs.

Teaching for transfer is necessary.

Transfer is greatest when content is similar.

Drill should be spaced and varied in type and amount.

Periodic review increases retention.

Immediate review of arithmetic test items increases achievement and retention.[2]

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[1]Neal, ibid., pp. 639-640.

[2]Marilyn N. Suydam and C. Alan Riedesel, "Research Findings Applicable in the Classroom," Arithmetic Teacher, XVI (December, 1969), p. 641.

Anttonen has reported the research for his dissertation in an article on attitudes. His results are significant positive correlation (at the .05 level) between elementary attitude scores and secondary attitude scores. He also found significant positive correlations between all measures of attitude and achievement. The subjects of his research were 607 students from an above average socio-economic suburb of St. Paul, Minnesota.[1]

In another study Pitkin investigated the attitudes toward mathematics of three classes of teachers and found no significant differences in their attitudes. The subjects were eighty-four teachers classed as (1) those who had a content course and a methods course in modern mathematics, (2) those who had only a content course in modern mathematics, and (3) those who had neither a content nor a methods course in modern mathematics during the last five years.[2]

Reys and Delon stated the results of a study on the attitudes of students who were pre-service elementary school teachers. Included as subjects in this study were students in these courses: (1) mathematics content course, (2) methods of teaching course, and (3) problems of teaching arithmetic

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[1]Ralph G. Anttonen, "A Longitudinal Study in Mathematics Attitude," Journal of Educational Research, LXII, 10, pp. 467-471.

[2]Tony Ray Pitkin, "A Comparison of the Attitudes Toward Mathematics and Toward Pupils of Selected Groups of Elementary School Teachers Who had Different Types and Amounts of College Education in Modern Mathematics," (University of South Dakota, 1968), Dissertation Abstracts, XXIX, 9 (March, 1969), p. 3025-A.

course. The conclusions were that sixty percent expressed favorable attitudes toward arithmetic and that the college courses produced some of these changes.

> It is not surprising that the observed changes in attitude toward arithmetic in only a few months of instruction were small since most of these attitudes were conceived at least five years prior to entering college and perhaps even cultivated through the years. A large scale improvement of these deep-seated feelings might be expected from high quality instruction in a continuous mathematics program for a longer period of time. However, the problem will not be alleviated until favorable attitudes toward arithmetic are fostered throughout elementary, secondary, and collegiate levels.[1]

A result of surveying research on attitudes toward mathematics was the conclusion that there is still a need to improve the attitude of the prospective elementary school teacher so that he may, in turn, improve the attitudes of his pupils. With this result clearly established, the fourth area of the survey is to be considered.

Audio-Tutorial Mode

Studies in mathematics using the multi-media technique of instruction, often referred to as audio-tutorial, are not found in the professional journals, not in the dissertation abstracts. The studies that approximate this mode of instruction would be studies that use these techniques: (1) programmed instruction; (2) audio-tapes; (3) films; (4) television; or (5) laboratory.

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[1]Robert E. Reys and Floyd G. Delon, "Attitudes of Prospective Elementary School Teachers Towards Arithmetic," Arithmetic Teacher, XV (April, 1968), p. 366.

The Laboratory

Three studies used a laboratory-learning situation in the research. The first study was a laboratory for high school students, a laboratory with multi-sensory aids and manipulative devices used to clarify concepts and arouse interests.[1] The second article was a report of a mathematics laboratory for prospective teachers, a laboratory for a class which is a combination of the three courses usually taught to prospective elementary teachers: (1) the content course; (2) the methods course; and (3) the problems in teaching mathematics course.[2] The third study was not reported as a study. Houston referred to it as a pilot study.[3] Fitzgerald described the results of his pilot study as a description of a successful innovation in individualizing instruction for large lecture groups by having some of the class sessions for small group laboratory activities.[4] As a part of this work

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[1]Nicholas H. Borota and Gladys M. Veitch, "Mathematics for the Learning Laboratory to Teach Basic Skills to Tenth, Eleventh, and Twelfth Graders in a Culturally Deprived Area," Mathematics Teacher, LXIII (January, 1970), pp. 55-56.

[2]David M. Clarkson, "A Mathematics Laboratory for Prospective Teachers," Arithmetic Teacher, XVII (January, 1970), pp. 75-78.

[3]W. Robert Houston, "Preparing Prospective Teachers of Elementary School Mathematics," Arithmetic Teacher, XV (November, 1968), p. 645.

[4]William M. Fitzgerald, "A Mathematics Laboratory for Elementary School Teachers," Arithmetic Teacher, XV (October, 1968), pp. 547-549.

with laboratory sessions Fitzgerald has a laboratory manual to be used in coordination with a text. A comparison of the two laboratory materials reported by Fitzgerald and by Clarkson showed that the materials are similar in nature.

Boonstra used in his study selected students at Michigan State University who had taken the mathematics course under Fitzgerald. He reported that these students did not transfer their learning in the laboratory to their teaching experiences--neither the use of materials nor the student-centered method of teaching.[1]

The studies by Fitzgerald and by Clarkson used the methods of teaching arithmetic to motivate learning. This approach to motivation, at least the direct use of methods, has been expressly rejected for community college courses by the curriculum planners and by the representatives from the four-year colleges who are responsible for approving the courses that will be accepted by the four-year institution for transfer credit.

Programmed Materials

A survey of the research on programmed instruction by textbook, machine, or computer has shown the interest in this mode of instruction. In 1966 May wrote an article on programming and automation in which he described the Skinner and

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[1]Boonstra, loc. cit.

the Crowder approaches to programming and also the programmed instruction by computer.[1] Nagel used a programmed textbook for his research in the teaching of remedial college algebra classes (intermediate algebra).[2] The results were not a significant improvement; however, the author set forth the conclusions that the failure rate was normal and, therefore, no harm was done to the subjects and (2) the amount of material covered was significantly more in the programmed group. Nagel also wrote of the student dissatisfaction and frustration for the group using the programmed material.

Alton reported the use of programmed material in a remedial algebra course at the college level with a degree of success for the programmed method. She did comment on the students' desires and need for discussion with a teacher.[3]

Two studies used programmed instruction in the first course in algebra. Sneider described the use of programmed learning to study achievement in a modern algebra class with the result that the programmed instruction was not better

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[1] Kenneth O. May, "Programming and Automation," Mathematics Teacher, LIX (May, 1966), pp. 444-454.

[2] Thomas S. Nagel, "Effects of Programmed Instruction in Remedial College Algebra Classes," Mathematics Teacher, LX (November, 1967), pp. 748-752.

[3] Elaine V. Alton, "An Experiment Using Programmed Material in Teaching a Noncredit Course at the College Level [with] Supplement," (unpublished Ph.D. dissertation, Michigan State University, 1965).

than the lecture demonstration instruction.[1] Devine did the research in student attitudes and achievement in teaching algebra I.[2] According to the results of the study (1) teachers reacted negatively to programmed materials and the inexperienced teachers more markedly than the experienced teachers, and (2) student attitudes were unaffected but achievement was significantly better in the traditional class. Devine recommended that "the use of short units as homework assignments . . . may be very helpful."[3]

Hennemann and Geiselmann made use of programmed instruction for the enrichment of a pre-calculus course. Students were satisfied with the programmed text but felt it took unnecessary fortitude and endurance to complete it. They expressed the feeling of a lack of interest and a need for contact with a "human" instructor.[4]

At Purdue University Bartz and Darby conducted a study on the effects of a programmed text in intermediate algebra

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[1]Sister Mary Joetta Sneider, "Achievement and Programmed Learning," Mathematics Teacher, LXI (February, 1968), pp. 162-164.

[2]Donald F. Devine, "Student Attitudes and Achievement: A Comparison Between the Effects of Programmed Instruction and Conventional Classroom Approach in Teaching Algebra I," Mathematics Teacher, LXI (March, 1968), pp. 296-301.

[3]*Ibid.*, p. 301.

[4]Willard W. Hennemann and Harrison A. Geiselmann, "Using Programmed Learning in the College Classroom: A Case History," Mathematics Teacher, LXII (January, 1969), pp. 27-32.

with one group to use the text in independent study. The control group, using a conventional text performed much better than did the experimental group.[1]

King studied group interaction with programmed instruction. This study is not significant for a research project that is designed to individualize instruction.[2]

Pethtel has used closed circuit television to teach college mathematics.[3] The course enrollment of 810 students included the subjects of the study, 263 elementary-teaching majors. The course outline for this mathematics course, a survey, covered the following topics; numeration systems, sets, logic, algebra, probability, and descriptive statistics. The methods of instruction used were (1) only television, (2) television and discussion, and (3) traditional. Results of the study are (1) that students in television achieved and retained as well as the other groups, (2) that upper ability students learned more by television than the lower ability students.

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[1]Wayne H. Bartz and Charles L. Darby, "The Effects of a Programmed Textbook on Achievement Under Three Techniques of Instruction," Journal of Experimental Education, XXXIV, 3, pp. 46-49.

[2]Robert W. King, "Using Programmed Instruction to Investigate the Effects of Group Interaction on Learning Mathematics," Mathematics Teacher, LXII (May, 1969), pp. 393-398.

[3]Richard D. Pethtel, "Closed Circuit Television Instruction in College Mathematics," Mathematics Teacher, LXI (May, 1968), pp. 517-521.

Audio Materials

The two studies using audio materials in mathematics classes were reviewed. The first research project as described by Robinson gave tape-recorded instruction on arithmetic performance of seventh grade pupils.[1] In his description of the analysis Robinson specified that the application of the Kuder-Richardson Formula 21 to a teacher-made test resulted in a cumulative reliability of .73. Fisher's "t" technique was used for the evaluation. The list of results obtained in this eight-week study are:

1. The traditional arithmetic instruction group performed at a higher rate than the tape arithmetic instruction group.

2. Average ability students who received traditional arithmetic instruction performed at a higher rate than pupils who received tape arithmetic instruction.

3. Girls who received traditional arithmetic instruction performed at a higher rate than the girls who received tape arithmetic instruction.

4. Average ability girls who received traditional arithmetic instruction performed at a higher rate than average ability girls who received tape arithmetic instruction.

[1]Frank Edward Robinson, "An Analysis of the Effects of Tape-Recorded Instruction on Arithmetic Performance of Seventh Grade Pupils with Varying Abilities," (North Texas University, 1968), Dissertation Abstracts, XXIX, 11 (May, 1969), p. 3782-A.

In the second study Byrkit used televised and aural materials for an in-service training program of junior high school mathematics teachers.[1] The components of this study consisted of a programmed text, a televised lecture, post-tape exercises, homework exercises, and a summary. Fifty-four teachers were randomly assigned to six groups. Three groups studied the lesson on integers and the other three groups studied the number theory lesson, each lesson studied in the three modes.

The television group showed greater superiority over the control group than the audio group over the control group. Strong possibility of type II error precluded acceptance of the hypothesis of no difference between the groups. The attitude survey showed more favorable attitude from the students who studied integers; the presentation mode made no significant difference in the attitudes.

In 1968 Zoll presented a summary of research on programmed instruction in mathematics.[2] He classified the studies by the alternate method; such as, traditional instruction, commercial programs compared to the conventional

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[1]Donald Raymond Byrkit, "A Comparative Study Concerning the Relative Effectiveness of Televised and Aural Materials in the In-service Training of Junior High School Mathematics Teachers," (Florida State University, 1968), Dissertation Abstracts, XXIX, 5 (November, 1968), p. 1463-A.

[2]Edward J. Zoll, "Research in Programmed Instruction in Mathematics," Mathematics Teacher, LXII (February, 1969), pp. 103-109.

methods, characteristics of learners, attitudes toward programmed instruction, changing the format of programs, teaching concepts, methods of teaching (guided discovery, expository). Zoll pointed out a need for still further research in programmed instruction.

Summary

In Chapter II the background of the problem has been presented in (1) the history and (2) the theory and the current literature on research, studies, and articles has been reviewed. The areas which were included were: elementary school mathematics teachers, community college students, attitudes toward mathematics, and the audio-tutorial method (substituting other related media of instruction). The following conclusions from the literature are of importance to this study:

1. Elementary teachers graduated from medium-city high schools understood mathematics more than teachers from large-city high schools.

2. Elementary teachers who prefer to teach mathematics understand mathematics better than other elementary teachers.

3. Elementary teachers who prefer not to teach mathematics understand less mathematics than teachers who prefer not to teach other classes.

4. In accordance with Committee on the Undergraduate Program in Mathematics recommendations, two or more college

mathematics courses are needed by a teacher who wishes to have a positive effect on the arithmetic achievement of his students.

5. Pre-service elementary teachers need mathematics courses that are specially designed to meet their needs, attitudes, and desires; courses for in-service teachers will not suffice.

6. Utilizing in the college mathematics courses the materials and tools that the elementary school teacher may be able to use in his teaching career will create a positive readiness, or set, toward these materials and tools for the prospective elementary teacher.

7. There is not sufficient evidence for drawing a conclusion about community college students, not enough to demonstrate a trend toward a conclusion. There is need for further study in this area.

8. Achievement in mathematics is related to prior achievement and jointly to prior achievement and attitude toward mathematics.

9. After a course in college mathematics at the University of Missouri, sixty percent of the pre-service elementary teachers have a favorable attitude toward mathematics.

10. The audio-tutorial mode of instruction as suggested by Postlethwait has not been tested for any of the research in mathematics and certainly not for mathematics for prospective elementary school teachers.

CHAPTER III

THE STUDY

Introduction

In this chapter are included (1) a detailed discussion of the problem, (2) the characteristics of the sample, (3) an evaluation of the measuring instruments, (4) the design of this comparative study of modes of instruction, (5) the hypotheses to be tested, (6) the methods to be used for that testing, and (7) a summary of the chapter.

Mathematics for Prospective Elementary Teachers

Delta College

In the fall of 1961, Delta College, a community college located near Bay City, Michigan, offered its first classes. The college district was governed by an autonomous board of trustees. Delta College, which had been planned and designed with the assistance and cooperation of the administration, faculty, and staff of Bay City Junior College, absorbed the Junior College into its organization, offering positions to the Junior College employees who wished to assume duties at Delta College. Many faculty members of the Junior College decided to make this change; some of these preferred to change rather than locate in a new area. Of course, new faculty members were also offered positions, since the enrollment increased even more than had been anticipated by the planners.

> It [Bay City Junior College] had been in existence 30 years and was one of the oldest public two-year colleges in Michigan. It was housed on the upper floor of a high school, was established, was accepted by the community, was reasonably predictable in its growth, was progressive, and suffered only from a lack of elbow room. No one seriously questioned its value or its contribution to the community.[1]

The Mathematics Department

At the opening of Delta College, the mathematics department was a department in the science division, but the mathematics department had duties and responsibilities that differed from those of the other science departments. Shortly after school opened the mathematics department prevailed on the administration for a change of classification and became an autonomous department, responsible through its chairman, Miss Meta Ewing, directly to Dean John Brinn, College of Community Services.

The mathematics department of Delta College consisted of eight faculty members, four experienced in teaching in a community college in the area, one from a community college in California, and three from high schools in Michigan. [see Table 1].

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[1]Eric J. Bradner, Report of the President, Schoolcraft College, 1960-1970, a printed report to the Board of Trustees. (Livonia, Michigan: Schoolcraft College, 1970), p. 1.

TABLE 1.--Mathematics Faculty at Delta College in the Fall, 1961.

Number	Area	Men	Women
4[a]	Bay City Junior College	2	2
1[a]	Community College in California	1	
1[a]	High School in Michigan		1
2[b]	High School in Michigan	2	
8		5	3

[a]College of Community Service

[b]College of Letters

Mathematics for Elementary Teachers

As the classes in mathematics for elementary teachers, Mathematics 110 at Delta College, progressed through the course, during the years from 1961-64 it became apparent to the instructors, who were new faculty members, that these classes were different from those in the other courses of the transfer curricula. Different student problems would develop in these sections. After some discussion of the problems arising from the diverse needs, desires, attitudes toward mathematics, and tensions resulting from frustration, as demonstrated by the overt behavior of the students, the instructors consulted the "older" mathematics faculty, or as they put it "Better ask a BCJC for help on that one!"[1]

[1]Bay City Junior College

The instructors were assured that this was the typical pattern for students enrolled in the course and that the anxiety-frustration rate, was the same as at other colleges, including the four year colleges and universities.

Schoolcraft College

In the fall of 1964, Schoolcraft College, a community college in Livonia, Michigan, offered its first classes, with a beginning enrollment of approximately 2000 students. Schoolcraft College is governed by an autonomous board of trustees who are elected from the five communities of northwest Wayne County, which make up the college district: that is (1) Clarenceville; (2) Garden City; (3) Livonia; (4) Northville; and (5) Plymouth.

> Our history at Schoolcraft, although parallel in some ways with the example I have just cited, differs in one major respect. Here in northwestern Wayne County we have just gone through our first 10 years of living with the idea that we really do have an institution of higher education in our community. We are only now beginning to get used to it.[1]

As Schoolcraft College began to function in the fall of 1964, a small nucleus of administrators, instructors, and staff from Bay City Junior College and/or Delta College was on hand to provide experience in community colleges and/or in the area. The remainder of the administrators, faculty, and staff were from high schools, other community colleges, or colleges, in this state, or other states.

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[1] *Ibid.*

> Enrollment alone has increased 255 percent during the six years of the College's life. Faculty to teach the students has increased 335 percent. The amount of money needed to operate the College for one year has tripled.[1]

In a newly opened community college there was only one way for faculty members to judge the patterns of behavior and the needs of their students. That way was to compare the current observations with events and characteristics observed with the educational institutions, noting similarities and differences, in order to evaluate the current performance and to develop and apply corrective measures as they were called for. These evaluations were needed in the mathematics courses, especially in mathematics for elementary teachers.

The Mathematics Department

At Schoolcraft College, in 1964, the mathematics department was, as it has remained, directly responsible through its chairman to the Dean of Instruction. The department consisted of five instructors whose experience is shown in Table 2. The faculty at Schoolcraft College in the school year of 1964-1965 was similar to the faculty that taught at Delta College in 1961-1964.

The current mathematics department for the school year of 1969 and 1970 consisted of a larger staff to meet the greater student mathematics enrollments, as shown in Table 3.

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[1] Ibid., pp. 3-4.

TABLE 2.--Mathematics Faculty at Schoolcraft College in 1964-1965.

Number	Community College in	Men	Women
2	Wayne County	1	1[a]
2	Michigan (Not Wayne County)	1	1
1	Out of Michigan	1[b]	
5		3	2

[a]Left for other position in Michigan

[b]Left for position out of Michigan

TABLE 3.--Mathematics Faculty at Schoolcraft College in 1969-1970.

Number	Faculty Service Begun	Faculty Service Extent[a]	Men	Women
3	1964-	6 years	2	1
2	1965-	5 years	2	
3	1968-	2 years[b]	3[b]	
2	1969-	1 year[b]	2[b]	
10			9	1

[a]Extent of service included 1969-1970

[b]Probationary status

During the six years Schoolcraft College has been in operation the mathematics instructors have noticed and have remarked on the characteristics of the students who enroll in mathematics for elementary teachers, designated as Mathematics 103 at Schoolcraft College.

The Course, Mathematics for Elementary Teachers

The enrollments in this course have increased in each semester so that, from 1964, with one section scheduled for each semester, this increase meant that in 1965 there were two sections each semester, and from 1968 on three sections were scheduled. For 1970-1971 there were scheduled three sections for the fall and four sections for the spring. At the suggestion of a mathematics instructor an evening class for Mathematics 103 was tentatively offered in the fall semester of 1965. This section, which had an enrollment of twenty students the first time it was offered (with limits on enrollment set at ten to thirty), has been offered each semester following that first offering.

In 1964 Mathematics 103, a three-semester hour course in modern mathematics at the arithmetic level, had no prerequisites and was the required mathematics course for the elementary education transfer curricula. It was, therefore, a requirement for the granting of an Associate of Arts degree by Schoolcraft College. On occasion, students from another curriculum have elected this course, because it has been, and still is, the only arithmetic course at Schoolcraft College that carries transfer credit and is accepted by liberal arts colleges.

The Motivation

The Mathematics 103 students at Schoolcraft College have displayed achievement behavioral patterns and attitudinal patterns similar to those "typical of the students at Delta College," according to the Bay City Junior College mathematics instructors.

A special mention should be made of the motivation problems involved in teaching this type of course. The students who are usually enrolled in this course in mathematics have already acquired the standards, aims, interests, goals, and reinforcement and reward systems of the American high school graduates of average ability (especially of the schools in the immediate vicinity). In their previous study of mathematics, some students have had no mathematics since the eighth grade. Others have had three years of high school mathematics. These three years of mathematics may be a combination of any of the following: general mathematics; commercial mathematics; applied mathematics; business arithmetic; or the usual college preparatory mathematics. Many of these students have developed attitudes toward mathematics which range from tentative hope of success to a feeling of uncertainty, dislike, distrust, and sometimes even dread.

At monthly meetings of the Southeastern Michigan Community College Mathematics Project and the annual meeting of Southeastern Michigan Association of Community College Mathematics Instructors, identified by SMCCMP and SMACCMI respectively, mathematics instructors from community colleges and four-year colleges and universities have refuted suggestions and statements that the patterns and trends described above were in any way different from those observed at their institutions. They asserted positively that the observations were similar.

At the Committee on the Undergraduate Program in Mathematics (CUPM) sponsored invitational Two-Year College Conference, held in September, 1969, at East Lansing, Michigan, and attended by mathematics faculty representatives of two-year colleges, and four-year colleges and universities throughout Michigan and the northwest part of Ohio, the members attending the section meeting on the mathematics for elementary teachers (NS)[1] proposal of CUPM insisted that these students have similar patterns whatever the institution they attend. The professors of the universities stated that they are teaching the same kinds of students as the instructor at the two-year college--the difference is the number of students in the section and not the kind of student.

In these sections there are, noticeably, two classes of students which are characterized by the time lapse between high school graduation and the enrollment in this course. The time lapse between the periods of attending "school" and

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[1]Committee on the Undergraduate Program in Mathematics Proposal of one year mathematics course in the number system. See Mathematical Association of America, A Transfer Curriculum . . ., pp. 40-47.

the age difference of these two groups is much more pronounced in Mathematics 103 than it is in the other courses in the mathematics department (in the day sessions), as Table 4 will show.

TABLE 4.--Students Enrolled in Mathematics 103 and 112 During 1968-1969, By Age (given in percent).

		1968		1969	
		Winter	Fall	Winter	Fall
Math 103	younger →1	85	84	78	76
	older[a] →1	15	16	22	24
Math 112	younger →1	93	89	91	86
	older[a] →1	7	11	9	14

[a]Older is defined as over twenty years of age, or more than two years since graduation from high school.

As the number of enrollments of the older students increased more rapidly than the enrollment of the younger students, adjustments had to be made in the teaching techniques in order to provide learning situations that would give all the students a maximum opportunity to learn the concepts of of the course. These older students differed from the younger students in one or more of the following characteristics:

1. They take more time to learn the same amount of material, especially as the course begins.

2. They persevere longer and strive harder.
3. They set higher standards of achievement for themselves, on the individual assignments and during the entire course.
4. They want to learn as much as they can so that they will be better prepared to teach arithmetic.
5. They develop more tension, anxiety, or frustration than the younger students do.
6. They usually have more and sometimes pressing family responsibilities or emergencies.

Unless Mathematics 103 can be a rewarding learning experience many of these students will continue in their current unfavorable attitudes toward mathematics.

As prospective elementary school teachers these students will be expected to teach arithmetic in the future and they would communicate their true attitudes toward arithmetic to their pupils, even when they were attempting to conceal these antipathies. When their pupils sensed the real attitudes of these teachers they would become even more concerned about their arithmetic. In order to avoid this situation it was necessary to develop in the Mathematics 103 students a sense of security and satisfaction in mathematics and to increase the motivation in these students to the level at which they could and would perform to the best of their abilities without at the same time developing the extreme anxieties and frustrations which would interfere with learning and achievement; this was, and is, one of the challenges of instructing the mathematics class for prospective elementary school teachers.

Attempts to Improve the Situation

To date the efforts to provide a better learning situation have been three-fold:

1. A pre-requisite for this course, Mathematics 45 or a satisfactory score on the Mathematics Admissions Test, was placed in the college catalogue two years ago. Until the fall semester of 1970 the test was used for data gathering purposes and voluntary placement. This pre-requisite will be required of all enrollees, beginning in the fall semester of 1970, since current study reinforced the basis for this decision.
2. The inception of a three-hour course, Mathematics 104, has been approved for the winter semester of 1971. This course was designed to give students the opportunity to have a full year of arithmetic, in accordance with the Committee on the Undergraduate Program in Mathematics recommendation. Course outlines appropriate for such courses at community colleges have received approval from mathematics representatives of the four-year colleges and universities at the April 9, 1970, meeting of the Southeastern Michigan Community College Mathematics Project at Oakland Community College at

Orchard Hills, Michigan. These outlines were approved by the Section on Mathematics for Elementary Teachers at the May 11, 1970, meeting of the Southeastern Michigan Association of Community College Mathematics Instructors. This annual conference was held at Macomb County Community College in Warren, Michigan. [See Appendix A.]

3. By quietly demonstrating and reinforcing the attitudes of "Mathematics Is Fun," "Learning is Doing," and "Everyone (including teacher or student) has the right to make a mistake without being ridiculed," the students are encouraged to take an active part in the class sessions. Class discussions can cover any topics pertinent to the lesson or, time permitting, to mathematics in general. These discussions can provide daily feedback to students and to the instructor on the attitudes, anxieties, and achievements of the class.

An indirect approach to the problem has been tried with a small degree of success, an improvement in the attitude. Additional projects, which are based on number theory, set theory, arithmetic, algebra, and geometry, some of which were originally teacher-made tests used in junior high classes, are designed to do the following for the students (plans for projects proposed by students can be submitted for approval):

1. To decrease the extreme tension or anxiety that develops.
2. To give a sense of accomplishment to the student.
3. To offer enrichment topics and models for their future teaching.
4. To provide further and advanced practice in basic fundamentals.
5. To satisfy a need to create--curve stitching, designing, construction of solids, photographs of geometric figures in life situations.
6. To add a small score to the final average of the student.

These attempts to correct the situation do not make a direct attack on the problem. Re-teaching and other methods cannot be used because of the time limitation and because each concept included in the course outline is essential to student learning in the course. The questions to be solved were, "How can we provide the student with the materials and means to study as much as he wants?" "How can we provide him with assistance at the time that he feels the need for that aid?" "How can we help the student in Mathematics 103?" "How can we provide materials and tools to study the content of the course and to make the student feel that he is learning or achieving?" "How can we arrange to provide the assistance when the student asks for it and to provide a flexible time schedule for studying?"

The problem, then, is (1) to provide the opportunity to succeed in learning modern mathematics, (2) to maximize the improvement in the attitude toward mathematics, and (3) to develop a mind set or readiness toward the audio-visual techniques of teaching through the student's personal experiences with the techniques.

The Sample

In November, 1969, approval for the study was obtained from the administration at Schoolcraft College, with a marked degree of interest in the idea of innovation of this technique (audio-tutorial) in some of the other mathematics classes. The Mathematics 103 classes for the winter semester of 1969-1970 were, therefore, designated the sample for the study. This decision was made on the basis of the selection of this sample from the population of all students who have enrolled, were enrolling, or will enroll in this course at this college.

At the time of this decision, the printed college time schedule for the winter semester was circulated to faculty, students, and community, with pre-registration already completed. The classes had to be accepted as they developed at final registration, since they were scheduled for eight o'clock, nine o'clock, and ten o'clock. The experimental group, randomly selected, was the ten o'clock class. The determination was made before the registration process was completed but was not announced until the first day of class--when laboratory arrangements were announced. Class lists

were not yet available and, therefore, there was no foreknowledge of the characteristics of the groups.

The class enrollments are limited to thirty students, with the exception that the instructor may give approval for admitting a student to his class, even if it has been announced as closed.

Information on the Mathematics 103 classes was obtained at the second class session from a math card [the current card is an adaptation of a math card used at Delta College, which was in turn a revision of the original version used at Bay City Junior College]. [See Appendix E]. These classes had the enrollment pattern that is shown in Table 5.

TABLE 5.--Number of Students Enrolled in Mathematics 103 by Sections in Winter of 1970 at Schoolcraft College.

Class	Initial	Adds[a]	Drops[b]	Final Enrollment
8:00	23	1	3	21
9:00	27	5	3	29
10:00	25	6	4[c]	27

[a]Adds must be completed within one week.

[b]Drops must be completed within four weeks not to become a part of the student's record.

[c]One drop was much later than the fourth week (WP was grade given); drop was due to difficulties unrelated to this study or to school.

The final enrollment of Mathematics 103 was seventy-seven students, with two groups of twenty-one and twenty-nine students to be the control groups and the section with twenty-seven students was the group for the experimental or audio-tutorial mode of instruction. The students who dropped the course in the first four weeks transferred to the non-credit course, Mathematics 45, or to courses in other departments, with the exception of the one student. That student, in the experimental group, was achieving his goals and his average was well above passing when he was forced by an emergency situation to drop out of the class, or to miss so many classes that his work would become unsatisfactory. The data on the sample characteristics were compiled into a table for easier reference and comparison of the group characteristics. [See Table 6.]

From the data in Table 6, the largest groups of students would be: (1) in a ratio of 17 to 20, from a public high school and single; (2) in a ratio of 3 to 4, under twenty years of age and directly out of high school, and (3) in a ratio of 3 to 5, college freshmen and from suburban high schools. This information from Table 6 made evident the individual differences of the students within each group that are apparent to educators. The students, or groups of students, that have one or more of the following characteristics are in a minority group in Mathematics 103: (1) male; (2) married; (3) older; (4) sophomore; (5) from an urban

TABLE 6.--Characteristics of Students Enrolled in Mathematics 103, Schoolcraft College, Winter Semester, 1970, (in percents to the nearest tenth).

		Sex		Marital Status		Age		Class		Attended High School in: City		Attended High School in: Type		Enrolled in College from High School	
Group	N	Male	Female	Single	Married	Younger	Older	Freshman	Sophomore	Urban	Suburb	Public	Private	Direct	Lapse
C_1	21	19.0	81.0	95.2	4.8	85.7	14.3	76.2	23.8	23.8	76.2	90.5	9.5	85.7	14.3
C_2	29	24.1	75.9	79.3	20.7	69.0	31.0	58.6	41.4	37.9	62.1	86.2	13.8	69.0	31.0
E	27	33.3	66.7	81.5	18.5	74.1	25.9	63.0	37.0	29.6	70.4	81.5	18.5	77.8	22.2
C_1+C_2	50	22.0	78.0	86.0	14.0	76.0	24.0	66.0	34.0	32.0	68.0	88.0	12.0	76.0	24.0
$\sum$	77	26.0	74.0	84.4	15.6	75.3	24.7	64.9	35.1	31.2	68.8	85.7	14.3	76.6	23.4

high school; (6) from a private high school, or (7) not directly from high school. As the size of the minority group grew larger in Mathematics 103, the composition of the group grew more complex and the problem of providing for the individual differences of the students in the section was compounded. The student frustration level increased accordingly. The data compilation was not carried out until the study was completed, in order to prevent the introduction of an independent variable into the study. An inspection of the data for the two control groups separately, the experimental group, the control groups as a unit, and the entire sample revealed that the arrangement of the groups with the characteristics in similar proportions were the (1) control groups as a unit and (2) the experimental group.

Additional information was available on the "math cards" for the students in the sample. The students enrolled in Mathematics 103 were usually, but not always, on the elementary education transfer curricula.

An inspection of Table 7 revealed that the sample is typical of the current trend at Schoolcraft College, the education students formed the major group in the sample and elementary education students were the largest part of the education group. Within the liberal arts group may be students who must be on this curriculum in order to transfer to Oakland University at Rochester on an elementary education program. Data were also collected on the four-year institutions

TABLE 7.--Transfer Curricula Selected by Students Enrolled in Mathematics 103, Winter, 1970 (given in percent, to nearest tenth).

Group	N	Education[a] Elem.	Sec.	Spec.	All	Lib Arts	Arch.	Music	Undecided
C_1	21	76.2	---	9.5	85.7	4.8	----	----	9.5
C_2	29	69.0	13.8	10.3	93.1	----	3.4	----	3.4
E	27	51.9	7.4	7.4	66.7	18.5	----	3.7	11.1
C_1+C_2	50	72.0	8.0	10.0	90.0	2.0	2.0	----	6.0
Total	77	64.9	7.8	9.1	81.8	7.8	1.3	1.3	7.8

[a]Education-Elementary, Secondary, Special, All.

to which Mathematics 103 students plan to transfer. The compilation of data is presented in Table 8.

The students enrolled in Mathematics 103 listed the same four-year institutions that the students in Mathematics 103 in the winter semester of 1967-68 listed. As can be seen from the table, a large majority of these students plan to attend universities in the immediate area (of less than 100 miles from home). Eastern Michigan University and Michigan State University have special programs arranged with Schoolcraft College for the elementary education students, which may account, in part, for the transfer plans of 67.5% of these students.

The sample, sections of Mathematics 103 enrolled in the winter semester of 1969-1970 at Schoolcraft College, did not differ from the population of Mathematics 103 students at Schoolcraft College--the students who have enrolled in the course, are enrolled in the course or will enroll in the course at this college. In addition to the data compiled from the information supplied by the students, the study was concerned with the tools for instruction and for measuring the effects of the teaching techniques on the groups.

The Audio-Tutorial Laboratory

At the first class session of the experimental group the laboratory arrangements were announced, that the class was excused from meeting for a third day each week, but each

TABLE 8.--Senior College Selected for Transfer by Students Enrolled in Mathematics 103, Winter, 1970 (given in percent, to nearest tenth).

Group	N	MSU	WMU	EMU	WSU	U of M	U of D	CMU	Gd Val.	Undecided
C_1	21	38.1	4.8	33.3		4.8			4.8	14.3
C_2	29	17.2	10.3	37.9	6.9	13.8		3.4		10.3
E	27	29.6	3.7	48.2	3.7		3.7			11.1
C_1+C_2	50	26.0	8.0	36.0	4.0	10.0		2.0	2.0	12.0
Total	77	27.3	6.5	40.2	3.9	6.5	1.3	1.3	1.3	11.7

student must select a convenient time on the laboratory time sheet and must sign up to come to the Mathematics 103 audio-tutorial laboratory for at least one hour a week. The laboratory was located in the listening room of the library. If there was more time and space yet available after the class members had signed up, the students would be permitted to work in the laboratory as long as they needed or wanted to do so. The lesson would be available to them for one week at a time.

The same text was used for all classes and the classes met for the same number of sessions.

The laboratory was located in the listening room of the library, away from the mathematics classroom area, with the result that only students who were involved in the experimental group would be coming to the laboratory. Four booths were reserved for use in the experiment and were equipped with audio-tape players and with slide viewers for 2" x 2" slides. There were two large round tables for small discussions or for checking the master key. The listening room was reserved for the experiment for these hours: from 10:00 to 3:00 on Monday and from 12:00 to 4:00 on Tuesday, Wednesday, and Friday.

The materials written and prepared for this study included the following: (1) behavioral objectives for eleven lessons; (2) slides--2" x 2" for the behavioral objectives--approximately 200 slides; (3) sets of assignment sheets for eleven lessons; (4) master audio-tapes for the eleven lessons; and (5) the four review sheets for the units and the course.

The behavioral objectives were written to give the students a clear understanding of what they should learn in the weekly lesson. [Appendix F].

The materials reproduced on slides were from two sources: either (1) designed and printed by the writer and then effectively photographed and mounted by a professional photographer; or (2) designed, drawn or written in colored chalk on a chalkboard, and photographed by the writer, and then developed by a commercial company.

In order to ensure the active participation of the student in the lesson at hand, the writer prepared assignment sheets for each laboratory lesson, requiring a variety of reactions; such as, (1) checking a correct response, (2) putting down the correct letter of a response, (3) writing a response in full, (4) doing assigned problems printed on a sheet of paper, and (5) writing answers on the paper to problems posed on the slide or on the audio-tape. Sometimes the student was directed to check with the instructor before proceeding with the lesson.

As each student entered the laboratory he signed in on his time card. Leaving this card at the desk, he picked up (1) the weekly audio-tape, (2) the set of slides, (3) the sheet of behavioral objectives, and (4) the assignment sheets for the lesson. He proceeded to his booth, set up his materials, and began his work. He would stop working if he needed to reflect on the concept or work at hand, if he needed to ask for assistance from the instructor, or if he wanted to check his assignment sheet against the weekly master key assignment sheet which was available (for his use) on the table at the side of the room.

Heeding the professional experience and judgment of Postlethwait,* to have the student identify with his instructor, the writer made the eleven master tapes to be used with the slides for the weekly lessons. The audio-visual department made the four copies needed for the weekly lessons.

The Measures

The Co-Variables

The Converted Rank in Class score which was used as the co-variable is the only score which Schoolcraft College now has in its admissions files on all students. The Converted Rank in Class Chart computed by Educational Testing Service transforms the student's rank in his graduating class to an equivalent standard score on a distribution with a mean of 50 and a standard deviation of 10. This device makes an adjustment for the student and his high school situation differentiating between the student who was 3rd in a class of 78 as contrasted with the student who was 32nd in a class of 700. The factor not included in this chart was the curriculum that the student followed. In a basic or beginning class at the level of Mathematics 103 the Converted Rank in Class score is a measure of the student's ability at his graduation from high school (76.6% of the Mathematics 103 students came directly from high school).

Data were collected on the Cooperative English Expression Test from Educational Testing Service, as a second co-variable. The Flint Junior College uses this test as one of two criteria for admission to the engineering technology curriculum. Data were collected on the Mathematics Computation Test which was constructed at Schoolcraft College within the last two years. Data were not available for this test because it was not a prerequisite for Mathematics 103 until last year--with the result that in the study sample there were sophomores and transfer students who had not taken the test. Norms have not been established for the test. For each student admitted to Schoolcraft College the Admissions Office collects the Converted Rank in Class score and the test scores as described above and sends these with the addition of the student's high school record to the counseling office for placement purposes ("open door" policy).

The Achievement Tests

One of the variables to be evaluated was the achievement of each student on each unit and on the final comprehensive examination. Heeding the professional opinion of Riedesel that non-appropriate standardized measures should be avoided, teacher-made tests were designed to evaluate achievement of the behavioral objectives of each unit and of the course.[1] Using the Kuder-Richardson Formula 21 the reliability coefficients were: unit I, .81; unit II, .74; unit III, .85; and final examination, .76. The tests are assumed to have both content and face validity since they cover the behavioral objectives for the material of the unit.[2] In a pilot testing the tests were administered to the students and the items were clear. No items were included that would favor one group over another.

The Testing Process

The review sheets were made available to all students a week before each test. The concepts to be covered on the test were among the items studied in the lessons for the unit and were listed on these sheets. The students were not told the exact nature of each question, but these forms had been covered fully in the lectures and in the laboratory.

A. At each testing period the student was supplied with (1) the packet of problem sheets, (2) the form answer sheet, and (3) two sheets of scratch paper.

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[1] C. Alan Riedesel, "Some Comments on Developing Proper Instrumentation for Research Studies in Mathematics," *Arithmetic Teacher*, XV (February, 1968), p. 166.

[2] George W. Schlinsog, "The Effects of Supplementing Sixth Grade Instruction with a Study of Nondecimal Numbers," *Arithmetic Teacher*, XV (March, 1968), p. 256.

B. At the end of the examination period, all materials were returned to the instructor, who added the master grading key to the papers and then turned all materials over to a paid non-student paraprofessional grader.

The Attitude Survey

The second variable to be measured was the attitude toward mathematics. The scale used for this purpose was designed to measure selected aspects of the attitude toward mathematics--areas that would be important to an elementary teacher in teaching mathematics.

The statements included in the scale were actually quotations, almost verbatim, of comments that had been made by various individuals, usually students, who were expressing their feelings toward mathematics at the moment. The scale was pilot tested on selected individuals, faculty members and paraprofessionals whose attitudes toward mathematics, both positive and negative, were already known. The scores were as expected and were correlated with attitudes. The respondees made suggestions for improvements. These were included in the revision, where other suggestions did not negate them. This revision was evaluated through Dr. Andrew C. Porter, Office of Research Consultation, Michigan State University. A second revision followed the evaluation incorporating the suggestions received from Dr. Porter.

The second revision was used in December, 1969, during the last week of regular class sessions to measure the attitudes of the students in Mathematics 103 and to make such evaluation a more routine incident for the next testing. There were two minor alterations to the scale for this occasion: (1) the statements on the laboratory, not being pertinent, were omitted, and (2) an extra sheet was added for an open-ended reaction, for comments on any area of the course that was of importance from the student's point of view.

The students had no difficulty in making decisions on the way they wanted to rate statements on the scale. The classes all reacted in a somewhat similar manner, with only minor variations which were not statistically significant.

As promised, after grades were turned in, the scales were evaluated and the comments were read and shared with selected faculty members who knew, taught, and advised these students. The scales did measure the student attitudes toward mathematics, and the students were frank and honest in their comments. The change in attitude toward mathematics was measured by the difference between attitude toward the course and attitude toward mathematics in school.

The Design

The study was a comparison of (1) achievement of students in two modes of instruction, the audio-tutorial and the conventional; and (2) the resulting changes in the attitudes of the students toward mathematics.

Of the three sections of Mathematics 103, Mathematics for Elementary Teachers, the ten o'clock class was randomly selected as the experimental group, to be taught by the audio-tutorial mode. The other two sections of Mathematics 103 were the control groups.

TABLE 9.--Experimental Design.

Group	Unit I	Unit II	Unit III	Exam	Attitude
C_1	$T_1 \rightarrow O_1$	$T_2 \rightarrow O_4$	$T_3 \rightarrow O_7$	$T_4 \rightarrow O_{10}$	A_{C_1}
C_2	$T_1 \rightarrow O_2$	$T_2 \rightarrow O_5$	$T_3 \rightarrow O_8$	$T_4 \rightarrow O_{11}$	A_{C_2}
E	$T_5 \rightarrow O_3$	$T_6 \rightarrow O_6$	$T_7 \rightarrow O_9$	$T_8 \rightarrow O_{12}$	A_E

T = Treatment[1]
O = Observation in form of a test.[1]
T_i = Lecture, discussion, questions, problem-solving (3 da/wk.) (i = 1, 2, 3, 4).
T_j = Lecture, discussion (2 da/wk.); audio-tutorial laboratory (1da/wk). (j = 5, 6, 7, 8).
O_k = Test on unit, or examination. (k = 1, 2, 3, . . . , 12).
A_m = Attitude scale. (m = C_1, C_2, E).

As advised, no pre-test was used because the unreliability of the data that could be gathered from these subjects did not warrant the administering of such a test. The analysis

[1]Adapted from: Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research, (Chicago: Rand McNally and Company, 1967), p. 51.

of covariance on the Converted Rank in Class score which had a correlation of .63 with the Mathematics 103 sections the semester it was computed (Fall, 1969). [One-way Ancova from Education 969C--Dr. Andrew C. Porter.][1]

One instructor taught all sections and the laboratory. This decision had to be made, with reluctance, and only after all alternatives were weighed and the professional judgment and experience of Postlethwait in the audio-tutorial mode of instruction was reviewed carefully.

The same text was used in all sections and the same concepts were presented to all sections. The difference in treatments consisted of the mode of instruction, the audio-tutorial laboratory, where the instruction was individualized, practice was sequenced and programmed, and the instructor was available to assist the student whenever he felt that he wanted aid. The student scheduled his time and could extend his time, or could leave and return later whenever he wanted to study; the laboratory was open on schedule and the materials were available.

The Hypotheses

The hypotheses that were tested, given in the form of null hypotheses are:

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[1]Ancova: Analysis of Covariance in the Finn Multivariate Analysis Program for Computer #3600.

1. No difference will be found in the achievement as measured by the mean scores of the groups on the test on Unit I, which is referred to as Test I; at the .05 level.

2. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Test II, at the .05 level.

3. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Test III, at the .05 level.

4. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Final Examination, at the .05 level.

5. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on the Tests, crossed with age, at the .05 level.

6. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Tests, crossed with direct/lapse time of entry to college, at the .05 level.

7. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Tests, crossed with private/public high schools, at the .05 level.

8. No difference will be found in the achievement of the groups, as measured by the mean scores of the groups on Tests, crossed with urban/suburban high schools, at the .05 level.

9. No difference will be found in the attitude of the students toward the seven/eight aspects of mathematics, as measured by their rating on the attitude scale, at the .05 level; or on the attitudes toward mathematics when crossed with each of the above categories of characteristics of the sample, at the .05 level.

The Analysis

The sample which was drawn from a "normal" population of Mathematics 103 students and which was typical of that population consisted of three sections of Mathematics 103. For the groups, there was normality, equal variances, and independence. The mean scores, standard deviations, and analysis of variance and covariance were carried out on the 3600 computer at the Michigan State University Computer Center. Assuming normality, equal variances, independence, parallel regression lines, and a linear relation between variable and co-variable, an analysis of covariance was carried out to correct for any influences that the lack of random sampling may have introduced into the study.

The Scheffé *Post Hoc* comparisons, the extension of the analyses of variance and covariance for testing the hypotheses, were used to identify the source of any significant variation in the study. An analysis of variance and covariance were carried out to test for significance of a change of attitude toward mathematics.

The Audio-Tutorial Mode

The audio-tutorial mode of instruction combined with the "modern mathematics" content that is used in elementary school arithmetic classes is an attempt to make the instruction in Mathematics 103 current and meaningful, as recommended by Spitzer:

> It also seems to me that the time has 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 is envisioned for the elementary school where these students are to teach.[1]

Summary

In this chapter the problem of providing Mathematics 103 students at Schoolcraft College with mathematics experiences that are individualized, motivating, instructive, and useful in teaching mathematics was described in more specific terms. The sample for the study was described: the Mathematics 103 sections in the winter semester of 1969-1970. The data collected on the sample showed that at least three out of every five students belong to one group with these characteristics: (1) young, single, female, freshman, came directly to college from a suburban, public high school from

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[1]Herbert F. Spitzer, "A Proposal for the Improvement of the Mathematics Training of Elementary School Teachers," Arithmetic Teacher, XVI (February, 1969), p. 137.

which she was graduated. Two out of every five students in the group differ from the above listed characteristics, in at least one of the characteristics.

Additional data were: 81.8% are in transfer programs in education (64.9% in elementary education) and most of these students plan to attend Eastern Michigan University (40.2%) and Michigan State University (27.3%).

Achievement was measured by four teacher-made achievement tests, one for each unit and a comprehensive examination for the course. These had been pilot-tested on a previous class. The attitude scale was designed and revised twice, before being tested in the Mathematics 103 students in the fall semester of 1969.

The design, which consisted of treating two sections of the sample as control groups with regular classes of lecture, discussion, question and answer, and testing; and the third section as the experimental group, with two classes a week of the regular type and the laboratory class in place of the third hour of class.

The technique for the study was unit of treatment followed by unit test for three units; then a short review period in both types of instruction before the final examination.

Text and concepts covered were the same for all groups.

Hypotheses were re-stated in null hypothesis form.

The analysis includes: means, standard deviations, correlations, analyses of variance, analyses of covariance, Scheffé's Post Hoc comparisons for significance, and an interpretation of the open-ended portion of the survey (attitudinal scale).

CHAPTER IV

EVALUATION OF THE AUDIO-TUTORIAL MODE

Introduction

The data were collected and the analyses were performed for the decision of the statistical significance in order to reject the null hypotheses of the study, whenever significance occurred.

Special note should be taken of the need to delete from the experimental data the four students who did not complete the course requirements, in addition to the students who were previously dropped as shown in Table 5, on page 69. The number of students in group $E^{\dagger}$ was, thereby, twenty-three. The analyses included both groups, E and $E^{\dagger}$. The inclusion of these four at the inception of the evaluation process was to insure objectivity in the process.

The null hypotheses on the achievement and on the attitudes toward aspects of mathematics were tested. The attitude toward the laboratory experience and the open-ended commentary were analyzed, last and separately.

The Statistical Techniques

Missing data arose for a variety of reasons: (1) a student was undecided about his vocation, or the transfer college; (2) a student was unresponsive to the attitudinal scale; (3) a student had not taken a test and did not have a reported score available; and (4) the students in the control groups could not evaluate their attitudes toward the audio-tutorial mode through direct experiences.

The missing data statistics program (MDSTAT) was used on the number 3600 computer at the Computer Center at Michigan State University to obtain the means, standard deviations and correlations for all variables of achievement, attitude, Converted Rank in Class score (CRC), Cooperative English Expression Test score, and Schoolcraft College Mathematics Test score.

An investigation of the interrelationships between (1) achievement with attitude within each group, (2) achievement with the laboratory time of the audio-tutorial group and (3) laboratory time and attitude toward mathematics for the audio-tutorial group was carried out by examining the correlation coefficients on (MDSTAT) print-out. The students in these groups were expecting to teach arithmetic in elementary schools and their attitudes toward arithmetic and toward achievement in arithmetic would be a factor of their success in teaching.

The analyses of variance and covariance were also computed on the 3600 computer, using Finn's Multivariance program (FINN), as recommended by the Office of Research Consultation, School for Advanced Studies, College of Education, Michigan State University. The analyses of covariance

were used to control for an inability to randomize the assignment of students in the sample to the treatment groups.

After the results of the analyses of variance or covariance led to the decision to reject the null hypotheses; then the Scheffé Post Hoc comparisons were used to identify the contrasts that were significant. This method was outlined in Education 969B - Quantitative Methods in Educational Research - at Michigan State University. The Scheffé Post Hoc method was recommended as the strongest approach to be used after rejection of the null hypothesis in a one-way analysis of variance or covariance, to gain more information on the significance at the same level of significance for all contrasts. (Not increasing the α level). After consideration of the weights and computation of orthogonal relationship in order to eliminate the redundancy of information, the two comparisons that were significant were (1) $E - \frac{1}{2}(C_1 + C_2)$ and (2) $C_1 - C_2$. Any others tested were for information that would be interesting and incidental to the study, but were recognized as containing redundant information.

The only co-variable for which data were consistently available from the student files was the Converted Rank in Class score (CRC) from the Educational Testing Service. Transfer students and students admitted to Schoolcraft College more than two years ago did not have scores for the Cooperative English Expression Test or the Schoolcraft College Mathematics Test. Schoolcraft College was in the process of selecting a placement battery that presented a more discriminating evaluation of a student's current educational status and a prediction of his future success at Schoolcraft College.

Converted Rank in Class score is a standard score with a mean of 50 and a standard deviation of 10, and it is used to reflect the size of the student's class and school, as well as the student's position in his graduating class. This score does not, however, reflect the curriculum that the student followed in his high school courses. This score has been accepted as reliable by other community colleges and is used with an English admissions test to admit to engineering technology programs at the community college level.

The Analyses

Introduction: The Co-Variable

As a basis for beginning the evaluation process of testing the hypotheses, a study of the Converted Rank in Class scores was made. The highest score, the lowest score, the range of scores, the mean score, and the standard deviation for each group was reported so that the characteristics of the groups would be in perspective. In Table 10 and all subsequent tables C is a control group, E is an experimental (AT) group, and T is the total of the three groups or the sample. $E^{\dagger}$ is E with four students deleted for failure to complete course requirements and $T^{\dagger}$ is T with the four students deleted. From Table 10 it was

TABLE 10.--Comparison of Mathematics 103 Groups on Converted Rank in Class Scores (The Co-Variable).

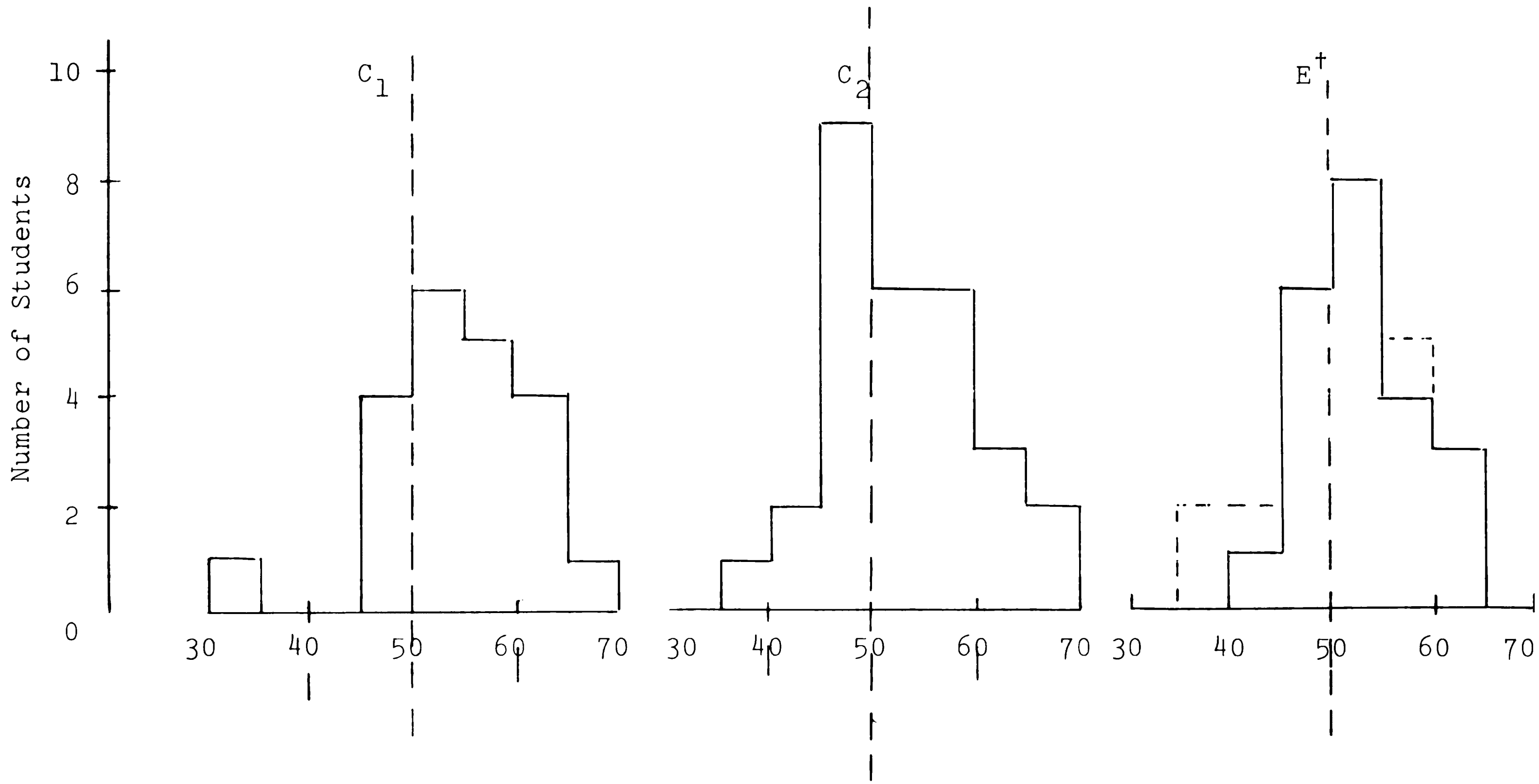
Group	N	Minimum Value	Maximum Value	Range of Values	Mean	Standard Deviation
C_1	21	32	69	37	53.476	7.916
C_2	29	37	69	32	52.552	7.859
E[a]	26	38	63	25	51.577	6.506
C_A	50	32	69	37	52.940	7.815
$E^{\dagger}$	22	44	63	19	52.864	5.185
T[a]	76	32	69	37	52.474	9.446
$T^{\dagger}$	72	32	69	37	52.864	9.427

[a]One student admitted by GED test - no CRC score.

C = Control group
E = Experimental (AT) group
T = Total sample
$E^{\dagger}$= E with four deletions
$T^{\dagger}$= T with four deletions
$C_A = C_1 + C_2$

apparent that the control groups had lower scores (CRC) than did the audio-tutorial group (for the control groups 32 and 37 and for the experimental group 38 or 44), but they had higher scores, also, of 69 as compared with 63. They had higher means and larger standard deviations. These differences would seem to give the advantage of prior achievement to the control groups.

From Figure 1, the control groups taken as a unit had three scores above 65; the audio-tutorial had none. The



Converted Rank in Class Scores in Intervals with a mean of 50 and standard deviation of 10.

Figure 1.--Converted Rank in Class Scores Groups C_1 C_2, and E+.

control groups had seven in the 60-64 interval and the audio-tutorial group had three. The scores are standard scores. The control groups, therefore had ten students who were more than one standard deviation above the mean, whereas the audio-tutorial group had only three in that interval.

A review of the characteristics of these groups, shown in Table 6, increased the basis for comparison of the two modes of instruction. A summary of the characteristics of the groups was established from the data collected:

1. The largest group of students was female, single, less than twenty years of age, and admitted directly from a public, suburban high school.

2. The characteristics of the other groups would yield the intersections of the sets of students who would be members of the sets above and of the complements of those sets.

3. The Converted Rank in Class score (CRC) mean scores for the groups showed that the ranges of the control groups were wider, with higher and lower values than those of the experimental group.

4. In the Converted Rank in Class scores (CRC) the mean score of the experimental group ($E^{\dagger}$) and the single mean for the students in the two control groups are very close in value.

5. The sample mean score of the Converted Rank in Class scores and the mean score of the $E^{\dagger}$ group are the same (52.864). The mean score of the C_1 group is above and the

mean score of the C_2 group is below this average value (52.864).

In addition to the characteristics of the groups, the correlations of the Tests and the Converted Rank in Class scores (the co-variable) were important to a clearer understanding of the analyses that were to be performed. These correlations were placed in Table 11. Garrett suggested testing for significance of correlations in two different ways. His second method of testing for significance of the correlation of two variables was used: (1) the number of subjects and the number of variables were determined; (2) the Table J was entered for two variables and (n-2) degrees of freedom; and (3) significance was determined whenever the r-value in the Table J was less than the r-value being tested.

All r-values are significant in the table, at .05 level, except in Test I, C_1 and $E^{\dagger}$, in Test II, C_2, and in Test III, C_2. Some of the r-values are significant at the .01 level, as marked in the table. These values indicate the rejection of the null hypothesis--no significance in the correlation of the Tests and the Converted Rank in Class scores.

For groups C_1, C_2, and $E^{\dagger}$, the correlations of the scores on the Tests and the Converted Rank in Class (the co-variable) scores were placed in Table 12 in order to evaluate the resultant effect on the Test correlations when

TABLE 11.--Group Correlations of Test Grades and Converted Rank in Class Scores.

Group	N	df	Test 1	Test 2	Test 3	Exam
C_1	21	19	0.3379	0.6488*	0.5717*	0.6481*
C_2	29	27	0.3897**	0.1895	0.3057	0.3812**
E	27	25	0.4147**	0.4987*	0.5443*	0.5481*
C_1+C_2	50	48	0.3715*	0.3701**	0.3783*	0.4524*
$E^\dagger$	23	21	0.3722	0.4514**	0.4164**	0.5359*
T	77	75	0.2801**	0.2700**	0.3498*	0.3701*
$T^\dagger$	73	71	0.2909**	0.2866**	0.3671*	0.3734*

*Significant at .01 level.[1]

**Significant at .05 level.

the data were controlled for the co-variable. The correlations in Table 12 are significant according to the chart supplied in Garrett's book.[2] The resultant correlations, when data were controlled for the co-variable, were put in Table 13. The entries in this table are somewhat smaller than the entries in Table 12, showing the effect of the co-variable was not as great as had been anticipated from the pilot study.

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[1]Henry E. Garrett, Statistics in Psychology and Education, 4th ed. (New York: Longmans, Green, and Company, 1955), pp. 397, 437-439.

[2]Garrett, ibid.

TABLE 12.--Matrix of Correlations of Tests and Converted Rank in Class Scores (Groups C_1, C_2, and $E^{\dagger}$).[1]

T	Test 1	Test 2	Test 3	Exam	CRC
Test 1	1.0000				
Test 2	0.5066*	1.0000			
Test 3	0.6827*	0.6618*	1.0000		
Exam	0.6863*	0.6279*	0.7707*	1.0000	
CRC	0.2801**	0.2700**	0.3498*	0.3701*	1.0000

Degrees of freedom = 70
*Significance at the .01 level (r>0.302)[1]
**Significance at the .05 level (r>0.232)[1]

TABLE 13.--Matrix of Correlations with Covariable, Converted Rank in Class, Eliminated (Groups C_1, C_2, and $E^{\dagger}$).[2]

	Test 1	Test 2	Test 3	Exam
Test 1	1.0000			
Test 2	0.4662*	1.0000		
Test 3	0.6502*	0.6289*	1.0000	
Exam	0.6533*	0.5903*	0.7368*	1.0000

Degrees of freedom = 69
*All significant at .01 level (r>0.302)[2]

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[1] Garrett, ibid.

[2] Garrett, ibid.

For groups C_1, C_2, and E, the correlations of the scores on the Tests and the Converted Rank in Class (the co-variable) scores were placed in Table 14 in order to evaluate the resultant effect on the Test correlations when the data were controlled for the co-variable, for this group also. The correlations in the Table 14 are significant, as marked, according to Garrett. The resultant correlations were put in Table 15. Here again, the entries are less than those in the original Test correlations, before controlling for the co-variable.

TABLE 14.--Matrix of Correlations of Tests and Converted Rank in Class Scores (Groups C_1,C_2, and E).

	Test 1	Test 2	Test 3	Exam	CRC
Test 1	1.0000				
Test 2	0.5149*	1.0000			
Test 3	0.6648*	0.6961*	1.0000		
Exam	0.6822*	0.6423*	0.7840*	1.0000	
CRC	0.2909**	0.2866*	0.3671*	0.3734*	1.0000

Degrees of freedom = 74

*Significant at .01 level (r>0.302)[1]

**Significant at .05 level (r>0.232)[1]

[1]Garrett, ibid.

TABLE 15.--Matrix of Correlations of Tests with Co-variable, Converted Rank in Class, Eliminated (Groups C_1,C_2, and E).

	Test 1	Test 2	Test 3	Exam
Test 1	1.0000			
Test 2	0.4707*	1.0000		
Test 3	0.6270*	0.6630*	1.0000	
Exam	0.6463*	0.6023*	0.7498*	1.0000

Degrees of freedom - 73.
*All significant at .01 level ($r>0.302$)[1]

With the methods of analysis decided and with knowledge of the groups involved in perspective, the results of the analyses were evaluated. Comments on these evaluations were reserved for the end of the chapter.

The Findings

Hypothesis 1

No difference was found in the achievement as measured by the mean scores of the groups on Test I, at the .05 level.

The mean scores of the groups were computed on the missing data statistics program (MDSTAT) and were compared for values. From Table 16 it was obvious that the mean scores in order of magnitude, from the largest to the smallest, were:

[1]Garrett, ibid.

$E^{\dagger}$, E, $T^{\dagger}$, T, C_1, $\frac{1}{2}(C_1 + C_2)$, and C_2. The range of the mean score values was 14.9 points. The audio-tutorial group (both $E^{\dagger}$ and E) mean score of performance exceeded the mean score of performance of all the sample ($T^{\dagger}$ or T) and every other group. The standard deviations for these groups were studied to estimate the variation of performance of each group. The standard deviations are given in Table 17.

For the groups C_1, C_2, and $E^{\dagger}$, the analysis of variance showed that there was significance in the difference of the mean score of achievement of the students on Test I at the .0107 level and therefore the null hypothesis was rejected for Test I. The data for this decision were put into the one-way analysis of variance, as printed by the computer. Appropriate data, which were selected from the computer print-out (FINN), were augmented from the missing data statistics program (MDSTAT) to form special tables for Test I, presented here for an easier interpretation of the hypothesis testing. The augmented data are marked off in Table 18 within the dotted lines.

The Scheffé Post Hoc comparisons technique was used to evaluate the contrasts already set up, (1) $E^{\dagger}-\frac{1}{2}(C_1 + C_2)$ and (2) $C_1 - C_2$. The result obtained was that significance was in the $E^{\dagger}-\frac{1}{2}(C_1 + C_2)$ comparison at .025 level, since zero is not a value included in the interval of 13.009 ± 12.303. The comparison is significant at the .05 level but not at the .01 level.

TABLE 16.--Mean Scores for Groups in Mathematics 103 on Tests, Examination, and Average, Winter Semester, 1970.

Group	N	Unit I	Unit II	Unit III	Final Exam	Average[a]
C_1	21	69.257	61.900	52.800	74.048	66.411
C_2	29	64.690	59.186	55.200	63.655	61.277
E	27	78.193	56.363	71.378	69.148	68.846
C_A	50	66.608	60.326	54.192	68.020	63.433
$E^\dagger$	23	79.617	60.352	76.617	73.913	72.882
T	77	70.670	58.937	60.218	68.416	65.333
$T^\dagger$	73	70.707	60.334	61.258	69.877	66.411

[a]Average grade is defined as sum of examination grades [final exam is weighted as two tests] divided by five.

TABLE 17.--Standard Deviations for Groups in Mathematics 103 on Tests and Final Examination, Winter Semester, 1970.

Group	N	Unit I	Unit II	Unit III	Exam
C_1	21	15.617	17.532	14.015	16.008
C_2	29	21.122	19.824	21.276	25.940
E	27	12.905	20.387	19.812	17.847
C_A	50	18.965	18.758	18.446	22.714
$E^\dagger$	23	12.935	18.148	16.268	13.561
T	77	17.124	19.437	19.033	20.875
$T^\dagger$	73	17.342	18.669	17.898	20.000

† 4 students deleted - did not complete course requirements.
$C_A = (C_1 + C_2)$

The analysis of covariance, the co-variable of Converted Rank in Class scores being controlled as the independent variable, showed that there was significance in the difference of the mean score of achievement of the groups on Test I at the .0041 level. The null hypothesis was rejected, again, for Test I. For the analysis of covariance, with augmented data, see the Table 19.

The Scheffé Post Hoc technique yielded the $E^{\dagger}-\frac{1}{2}(C_1 + C_2)$ contrasts as the significant difference in teaching techniques. The only other comparison to yield significance was the $E^{\dagger}-C_2$. The achievement of the audio-tutorial group was more effective on Test I than the achievement of the average of the control groups as measured by the mean scores of these groups: C_1, C_2, and $E^{\dagger}$.

For the groups, C_1, C_2, and E, the hypothesis of no difference in the achievement as measured by the group mean scores was tested by the analysis of variance and resulted in significance in the difference of the mean scores on Test I at the .0151 level. The data for the computation were presented in Table 20 which has been augmented in same manner as in Table 18.

The analysis of covariance showed significance in the differences of the mean scores at the .0041 level and, therefore, the null hypothesis was rejected for the difference in achievement on Test I. The Scheffé technique resulted in

TABLE 18.--One-Way Analysis of Variance for Test I (Groups C_1,C_2, and E†).

Source	df	Sum of Squares	Mean Squares	F Ratio	p less than
Between	2	2920.2752	1460.1376	4.8553	.0107[a]
Within	70	21051.1490	300.7307		
Total	72	23971.4242			

[ ] Augmented data.

[a]reject null hypothesis.

TABLE 19.--One-Way Analysis of Covariance for Test I (Groups C_1,C_2, and E†).

Source	df	Sum of Squares	Mean Squares	F Ratio	p less than
Between	2	3357.7994	1678.8997	5.9716	.0041[a]
Within	69	19680.3180	281.1474		
Total	71	23038.1174			

[ ] Augmented data

[a]reject null hypothesis

Covariable (CRC) eliminated.

the comparison, $E-\frac{1}{2}(C_1+C_2)$, being the significant difference at .025 level for the interval of 11.585±11.524. Zero was not included in the interval. The data for the analysis of covariance were placed in Table 21, with augmented data in the dotted line portion of the table.

TABLE 20.--One-Way Analysis of Variance for Test I (Groups C_1,C_2, and E).

Source	df	Sum of Squares	Mean Squares	F Ratio	p less than
Between	2	2607.0044	1303.5022	4.4452	.0151[a]
Within	74	21699.6268	293.2382		
Total	76	24306.6312			

[ ] Augmented data.

[a]reject null hypothesis.

TABLE 21.--One-Way Analysis of Covariance for Test I (Groups C_1,C_2, and E).

Source	df	Sum of Squares	Mean Squares	F Ratio	p less than
Between	2	3233.4612	1616.7306	5.9418	.0041[a]
Within	73	20134.9856	272.0944		
Total	75	23368.4468			

[ ] Augmented data.

[a]reject null hypothesis.

Covariable (CRC) eliminated.

Hypothesis 1: The Decision

The hypothesis of no difference in achievement of the groups as measured by the mean scores on Test I was rejected. The achievement of the audio-tutorial group was significantly better on Test I than the average achievement of the control groups, but not significantly better than each group. ($E^{\dagger}$ did perform better than C_2).

Hypothesis 2

No difference was found in the achievement of the groups as measured by the group mean scores on Test II, at the .05 level.

The group mean scores showed a reversal of position from that shown in Test I; for the rank order, in test II, from the largest value to the smallest, is: C_1, $E^{\dagger}$, $T^{\dagger}$, C_A, C_2, T, and E. The range of the mean score values was 5.537 points for Test II. The mean score values for all groups on all tests were placed in Table 16.

For groups C_1,C_2, and $E^{\dagger}$ the analysis of variance failed to yield results to reject the null hypothesis of no significant difference of group mean scores at the .05 level since the rating for p was .8795 on Test II. The analysis of variance for Test II was included in the analysis of variance of all tests on the computer print-out. The FINN computer print-out for all tests was placed in Table 22. A comparison of this table with the unmarked portion of Table 18 showed the data for the decision-making process, for each of the succeeding decisions, in turn. The FINN print-out was augmented with data from the (MDSTAT) program, shown by dotted lines.

For groups C_1, C_2, and $E^{\dagger}$ the analysis of covariance results did not indicate rejection of the null hypothesis for the difference of the group mean scores on Test II at .05 level, as p was less than .8768, as shown in Table 23.

TABLE 22.--One-Way Analysis of Variance (Groups C_1,C_2, and $E^{\dagger}$).

Variable	Mean Squares Between	Mean Squares Within	F Ratio	p less than
Test I	1460.1376	300.7307	4.8553	0.0107[a]
Test II	44.8563	348.5338	.1287	0.8795
Test III	3996.2627	320.3520	12.4746	0.0001[a]
Exam	931.2801	400.1547	2.3273	0.1051

Degrees of freedom for hypothesis = 2.
Degrees of freedom for error = 70.
[a]reject null hypothesis.

TABLE 23.--One-Way Analysis of Covariance (Groups C_1,C_2, and $E^{\dagger}$).

Variable	Mean Squares Between	Mean Squares Within	F Ratio	p less than
Test I	1678.8997	281.1474	5.9716	0.0041[a]
Test II	43.1850	327.9043	.1317	0.8768
Test III	4524.5682	285.2350	15.8626	0.0001[a]
Exam	1040.5328	350.3595	2.9699	.0580

Co-variable (CRC) eliminated.
Degrees of freedom for hypothesis = 2.
Degrees of freedom for error = 69.
[a]reject null hypothesis.

For groups C_1, C_2, and E the results obtained for Test II with the analysis of variance at .05 level was failure to reject the null hypothesis at .05 level, with p less than .6188. The data from the (FINN) print-out were presented in Table 24. The analysis of covariance results did not indicate rejection of the null hypothesis at .05 level (.8354). The data from the analysis of covariance print-out (FINN) were presented in Table 25.

Hypothesis 2: The Decision

The hypothesis of "no difference was found in the achievement of the groups as measured by the group mean scores on Test II" cannot be rejected at this time nor from these data. The decision at the present is failure to reject.

The result of this failure to reject would be misleading, if left without comment. The events occurring during the teaching of Unit II have had a greater effect on the audio-tutorial group than was anticipated. It was important to note that the lack of significant difference which resulted in the failure to reject the null hypothesis was not caused by the audio-tutorial laboratory mode. The variables that were interjected into the study at that time were, almost certainly, the factors responsible for the shift in the achievement in all the groups. One of these factors was the sequencing and programming of Unit II. It was not as thorough as that for Unit I and Unit III. Units I and III have been

TABLE 24.--One-Way Analysis of Variance (Groups C_1, C_2, and E).

Variable	Mean Squares Between	Mean Squares Within	F Ratio	p less than
Test I	1303.5022	293.2382	4.4452	0.0151[a]
Test II	182.5304	377.8315	.4831	0.6188
Test III	2624.1939	362.2626	7.2439	0.0014[a]
Exam	668.8949	435.7621	1.5350	0.2223

Degrees of freedom for hypothesis = 2.
Degrees of freedom for error = 74.

[a]reject null hypothesis.

TABLE 25.--One-Way Analysis of Covariance (Groups C_1, C_2, and E).

Variable	Mean Squares Between	Mean Squares Within	F Ratio	p less than
Test I	1616.7306	272.0944	5.9418	0.0041[a]
Test II	63.3790	351.5197	.1803	0.8354
Test III	3329.0536	317.7366	10.4774	0.0001[a]
Exam	692.3521	380.1417	1.8213	0.1691

Co-variable (CRC) eliminated.
degrees of freedom for hypothesis = 2.
degrees of freedom for error = 73.

[a]reject null hypothesis.

used previously and revised in another form. [See Appendix G].

The amount of material covered in Unit II (concepts) and the

complexity of the material was even more difficult for the students than had been anticipated. The second factor was that the Mathematics 103 classes had to be cancelled for one week and this cancellation occurred during Unit II. All of the classes were affected differently by this loss of class time.

Hypothesis 3

No difference was found in the achievement of the groups as measured by the group mean scores on Test III, at the .05 level.

The mean scores of the groups, when arranged in rank order from the largest to the smallest value, were: $E^{\dagger}$, E, $T^{\dagger}$, T, C_2, C_A, and C_1: the range of these mean scores was 23.817 points. The mean scores were placed in Table 16.

For the groups C_1, C_2, and $E^{\dagger}$ the analysis of variance showed significance at the .0001 level in Table 22 and, when the Scheffé Post Hoc comparisons method was applied, the contrasts that showed significance in the difference of group mean scores were:

1. $E^{\dagger} - \frac{1}{2}(C_1 + C_2)$ with the interval, 22.425 ± 14.291.
2. $E^{\dagger} - C_1$ with the interval, 23.817 ± 16.437.
3. $E^{\dagger} - C_2$ with the interval, 21.417 ± 15.760.

The $C_1 - C_2$ comparison did not prove significant, since zero was in the interval, which meant that when $C_1 - C_2$ equalled zero, then C_1 would equal C_2, and the null hypothesis should not have been rejected.

The results of the analysis of covariance showed significance for Test III at the .0001 level and the comparisons above were again significant, though the values were not the same for the intervals. The data were placed in Table 23.

For the groups C_1, C_2, and E the results of the analysis of variance showed significance at the .0041 level on Test III in the Table 24. The Scheffé Post Hoc comparisons gave the $E - \frac{1}{2}(C_1 + C_2)$, $E - C_1$, and $E - C_2$ as significant, but again $C_1 - C_2$ was not a significant comparison. The results of the analysis of covariance showed a significant variance at the .0001 level. The comparisons listed above were the signifiant comparisons for Test III. The data for the comparisons were shown in Table 25.

Hypothesis 3: The Decision

The null hypothesis of "no difference in the achievement of the groups as measured by their mean scores on Test III, at the .05 level," was, therefore, rejected (.0001).

Hypothesis 4

No difference was found in the achievement of the groups as measured by the group mean scores on the final examination.

The group mean scores, when arranged in rank order, from the largest to the smallest, were: C_1, $E^{\dagger}$, $T^{\dagger}$, E, T, C_A, and C_2. The range of mean score values was 10.393 points.

The results of the analysis of variance for groups C_1, C_2, and $E^\dagger$ showed no significant differences for the final examination with a value of p less than .1051 in Table 22.

The results of the analysis of covariance for groups C_1, C_2, and $E^\dagger$ also showed no significant variation for the final examination with a p at the .0580 level, in Table 23.

For the C_1, C_2, and E groups the results of the analysis of variance and the analysis of covariance showed no significant variations with values of .2223 and .1691, respectively, in Table 24 and 25, respectively.

The group mean score of C_1 resulted from a reaction to the scores the students received on Test III. Those scores had increased the student's need to raise his average, in order to pass the course.

Hypothesis 4: The Decision

The decision was failure to reject the null hypothesis of no difference in achievement of the groups as measured by the group mean scores on the final examination. The data would not at this time permit rejection.

Hypothesis 5

No difference was found in the achievement of the groups as measured by the group mean scores on the Tests (including examination), crossed with age, at the .05 level.

From the table below it was apparent that age was a factor of the variation in achievement of the groups and from

the mean scores it was apparent the group mean score for the older students was significantly better than the group mean score of the younger students. In every test category the Converted Rank in Class mean score for the older students was less than the mean Converted Rank in Class score for the younger students in the groups C_1, C_2, and $E^{\dagger}$. From Table 26 it was seen that the older students performed better on Test III and for the groups C_1, C_2, and E the performance on the examination was also significant to these groups, older and younger students.

TABLE 26.--Summary of Decisions to Reject.

Group	Test	Means Difference $(\bar{O}-\bar{Y})$	p less than		Contrast
			Anova	Ancova	
$C_1, C_2, E^{\dagger}$	III	11.7007	0.0549[a]	0.0464[a]	O - Y
C_1, C_2, E	III	12.8285	0.0336[a]	0.0298[a]	O - Y
C_1, C_2, E	Exam	11.8016	0.0569	0.0444[a]	O - Y

[a]reject at .05 level.

The mean scores of the older students were consistently higher on the tests than the mean scores of the younger students, as was shown in comparing the mean scores; the results were placed in Table 27 below.

TABLE 27.--Differences of Mean Scores on Tests, Groups Controlled for Factors.[a]

Test	Age[b] Older — Younger $E^{\dagger}$	Age[b] Older — Younger E	Lapse-Direct $E^{\dagger}$	Lapse-Direct E	Urban-Suburban $E^{\dagger}$	Urban-Suburban E
Test I	+ 3[c]	+ 2[c]	+ 2	3	3	3
Test II	+ 7[d]	+ 9[d]	+13	+12	4	7
Test III	+12[c]	+13[c]	+ 5	+ 5	5	8
Exam	+11[d]	+12[d]	+ 7	+ 8	1	3

[a]Private, public high schools differed by only one point.

[b]Grouping in 5 levels by age resulted in Group II mean score being the highest consistently (23 to 27 years of age).

[c]Mean score above mean score of control groups; below mean score ($E^{\dagger}$).

[d]Mean score above all mean scores in Test, groups uncrossed.

Hypothesis 5: The Decision

The null hypothesis of no difference in achievement of groups as measured by the mean scores of the groups on the Tests, crossed with age, was rejected for Test III for both sets of groups C_1, C_2, and $E^{\dagger}$ and C_1, C_2, and E; therefore, for Test III the fourteen older students achieved a significantly higher mean score than did the sixty-three younger students. The older students were defined as more than twenty years of age and/or more than two years from high school graduation.

Hypothesis 6

No difference was found in achievement of the groups as measured by the group mean scores on the Tests, crossed with "lapse/direct from high school" classification. The differences of the mean scores for these two groups ($\bar{L} - \bar{D}$) on the tests was placed in Table 27. The group mean Converted Rank in Class score was less on each of the tests for the "lapse" group than for the "direct" group. However, from Table 28 it was seen that the "lapse" group achieved a higher mean score than did the "direct" group in both the $C_1, C_2, E^\dagger$ and C_1, C_2, E groups.

TABLE 28.--Summary of Decisions to Reject.

Group	Test	p less than		Comparison
		Anova	Ancova	
$C_1, C_2, E^\dagger$	II	0.0111[a]	0.0085[a]	L - D
C_1, C_2, E	II	0.0247[a]	0.0156[a]	L - D

[a]reject null hypothesis.

Hypothesis 6: The Decision

The null hypothesis was rejected for only Test II for both sets of groups with the students classified as the "lapse" group achieving a significantly higher mean score.

Hypothesis 7

No difference was found in the achievement of the groups as measured by the group mean scores on the Tests, crossed with the public/private school classification.

The mean scores differed by only one point and the results of the analysis of variance and the analysis of covariance did not reveal significance.

Hypothesis 7: The Decision

The data did not show significance and the results of the analyses led to the decision to fail to reject the hypothesis, for this set of data.

Hypothesis 8

No difference was found in the achievement of the groups as measured by the group mean scores on the Tests, crossed with the classification of urban/suburban.

The differences of the group mean scores were put in Table 27. The data were used to test the null hypothesis by the analysis of variance and the analysis of covariance. No significance was revealed.

Hypothesis 8: The Decision

The data analyses resulted in the decision to fail to reject the hypothesis for the data collected.

Hypothesis 9

No difference in the group mean rating of the students was found in the attitude of the students toward the seven (or eight) aspects of mathematics, as measured by their rating on the attitude scale, at the .05 level; or on the attitudes toward mathematics when crossed with each of the above categories of characteristics of the sample, at the .05 level.

The missing data statistics program (MDSTAT) on the computer gave the mean scores for these seven categories. The mean scores were put in Table 29. The E group had a higher mean in all categories, except method, which referred to the textbook and class work and not to the laboratory. In all categories except the school, the ratings are above three, which means a more favorable attitude toward mathematics has replaced a less favorable attitude--the result of elementary and high school mathematics. The difference, course minus school, was a value of +.500 for the total group and +.566 for the $E^{\dagger}$ group (.592 for C_2). All the differences were positive, which indicated an improvement of attitudes at the end of the course.

The results of the analyses of variance and the analyses of covariance are presented in Table 30. Investigation of the analyses was extended to a different grouping arrangement to ascertain the effect of the mode of instruction as a possible cause for failure to complete the course requirements and of the effect their deletion had on the statistical analyses. The deletion had decreased the number of rejections of the null hypotheses on attitude and, therefore, it was apparent that those deleted from the study did not dislike only the audio-tutorial laboratory mode of instruction, but still disliked mathematics so much that they could not, or would not, attend the classes for discussion, or the laboratory. Three of these students were below the mean, more than one standard deviation below on the Converted Rank in Class score. This low score meant that high school achievement had been low.

TABLE 29.--Attitude Toward Mathematics as Measured by the (t is light) Means of Responses by Students on Attitude Scale.[a]

Group	N	General Attitude	Elem. & Second. School	This Course	Teaching Math	Method in General	Modern Math	Total	Course Minus School
C_1	20[b]	3.342	2.900	3.383	3.600	3.733	3.800	3.400	+.483
C_2	27[c]	3.247	2.667	3.259	3.244	3.469	3.852	3.245	+.592
E	27	3.648	3.210	3.620	3.644	3.679	3.870	3.583	+.410
C_1+C_2	47	3.287	2.766	3.312	3.396	3.582	3.830	3.311	+.546
$E^\dagger$	23	3.616	3.130	3.696	3.591	3.623	3.891	3.567	+.566
T	74	3.419	2.928	3.428	3.486	3.617	3.845	3.410	+.500
$T^\dagger$	70	3.395	2.886	3.438	3.460	3.595	3.850	3.395	+.552

Scale low 1→5 high

[a] Data from <u>MDSTAT</u> computer program.

[b] One unfinished rating scale turned in.

[c] Two absent - didn't respond at all.

TABLE 30.--Summary of Decisions to Reject.

Group	Category	p less than: Anova	p less than: Ancova	Interpretation
$C_1, C_2, E^{\dagger}$	Course	0.0487[a]	0.0289[a]	reject
	General	0.0652	0.0460[a]	reject
	Total	0.0882	0.0532[a]	reject
C_1, C_2, E^{-5}	Course	0.0482[a]	0.0427[a]	reject
C_1, C_2, E^{-1}	General	0.0406[a]	0.0230[a]	reject
	School	0.0661	0.0345[a]	reject
	Course	0.0634	0.0354[a]	reject
	Total	0.0602	0.0312[a]	reject

[a]Significance noted.

$E^{\dagger}$Experimental group, with 4 deletions.

E^{-1}Experimental group minus student admitted with GED only.

E^{-5}Experimental group minus 5 students.

In all three sets of the groups the hypothesis was rejected for attitudes: the course; general; and total attitude toward mathematics.

The Scheffé Post Hoc comparison method showed the $E^{\dagger}-\frac{1}{2}(C_1 + C_2)$ to be the significant contrast.

The attitude categories, when crossed with the younger/older, direct/lapse, suburban/urban, and public/private classifications did not show a significant variation in the analysis of variance or in the analysis of covariance.

Hypothesis 9: The Decision

The null hypothesis was rejected for the attitude toward mathematics in only three of the seven categories: (1) the course; (2) general; and (3) total. The source of the variation significance was the experimental group minus the two control groups as a unit or $E^{\dagger}-\frac{1}{2}(C_1 + C_2)$.

The Laboratory

Addendum to Hypothesis 9

The attitude toward a mathematics laboratory was evaluated separately, because it was not a treatment given to all groups. The audio-tutorial group responded to actual experiences in the laboratory. The students in the control groups responded, if they so desired, on the basis of conjecture and opinion of the probable effect of such a laboratory on their achievement. The last three statements on the attitude scale in Appendix C were related to the laboratory experience. The mean scores for these responses were shown in Table 31.

These mean values reflected the willingness of our Mathematics 103 students to use the laboratory, if it were available or if it were to be made available. The consensus of opinion was favorable to a laboratory. Looking at the rating for the audio-tutorial group (E or $E^{\dagger}$) as in Table 31 it was obvious that the group using the laboratory was decidedly in favor of this mode of instruction.

A review of the individual Converted Rank in Class scores and the test scores showed that second control group

TABLE 31.--Mean Values of Student and Responses to Audio-Tutorial Laboratory in Mathematics 103.

Group	N	Statements	
		25,26	25,26,27
C_1	8 (21)	3.813	3.708
C_2	24 (29)	4.146	3.944
E	27 (27)	4.537**	4.321*
$\frac{C_1+C_2}{2}$	32 (50)	4.063	3.885
$E^{\dagger}$	23 (23)	4.609**	4.362*
T	59 (77)	4.280	4.085
$T^{\dagger}$	55 (73)	4.370	4.085

Scores range from 1 to 5 as the attitude toward mathematics becomes more favorable.

Statement 27 reflects in part the frustration level.

Statements 25 and 26 reflect the student's opinion of the value of the laboratory--the relation of the laboratory to his success in the course.

also needed the additional practice and assistance that would have been available in a laboratory. The attitude values of this group in Table 31 led to the conclusion that these students were aware of this need, since more of this group responded to these statements on the scale, and the mean value for this group was larger than that of the first control group.

The group correlation ratios on the seven aspects of attitudes toward mathematics showed an awareness of the two control groups toward mathematics and the aspects noted. In the control groups the achievement and the attitude correlate significantly, at the .05 level. The experimental group achievement and attitude were positively correlated, but not large enough to be significant--significant correlations are shown in Table 32.

Consideration of the mean values on the attitudinal ratings did not clarify the investigation. A comparison of the correlation of achievement and attitudes toward the audio-tutorial laboratory revealed no significant ratios. However, a further inspection of Table 33 led to the considered opinion that the opportunity to use the laboratory had affected the experimental group. These students had had the use of the laboratory and had no conception of what the regular class work would have meant to their success in learning.

In contrast, the control students were definitely aware of the need for further assistance. The negative correlations would lead to the conclusion that the students who were receiving the lower grades on the tests were the students who most desired the laboratory.

The individual open-ended comments on the course were arranged by groups and were placed, without editing, in Appendix H.

TABLE 32.--Correlation of Achievement and Attitudes Toward Mathematics by the Groups.

Group	N	df	Test 1	Test 2	Test 3	Exam
C_1	21	19	school teaching* total	general course teaching total	general course* total*	general* teaching total
C_2	29	27	general course* teaching* total*	general course teaching total	general* school* course* teaching* total*	general school course* teaching* total
E	27	25	modern	a	a	a
E†	23	21	a	a	a	a
C_1+C_2	50	48	general* school* course* teaching* total*	general* course* teaching* total*	general* school* course* teaching* total*	general* school* course* teaching* total*

all are significant at .05 level.[1]
*significant at .01 level.[1]
[a]non-significant at .05 level.[1]

Significant negative correlations were found between the Schoolcraft College Mathematics Test scores and the time spent in the laboratory per unit per student.

Correlations of Mathematics Test and Laboratory Time Per Unit.

	Unit I	Unit III	Unit III	Exam
Math Test	-0.4041	-0.2445	-0.4469	-0.4281

[1]Garrett, _ibid_.

TABLE 33.--Correlations of Achievement and Attitude Toward Audio-Tutorial Laboratory.

Group	N	df	Test I	Test II	Test III	Exam
C_1	$^{8}(21)$	6	-.4879	+.1993	-.0015	-.3263
C_2	$^{24}(27)$	22	.0189	-.0050	-.1835	.0053
C_1+C_2	$^{32}(49)$	30	-.1389	.0621	-.0819	-.0982
E	$^{27}(27)$	25	.2385	.1822	.2889	.3079
$E^{\dagger}$	$^{23}(23)$	21	.2294	.2315	.3077	.3277

None are significant at .05 level.[1] [small n's]

These correlations indicated that the student who needed the laboratory for assistance did spend time in the laboratory learning mathematics.

In order to collect and summarize the decisions presented in this chapter as effectively as possible, the decisions have been arranged in tabulated form and placed in Table 34.

[1]Garrett, *ibid*.

TABLE 34.--Summary of Decisions.

No difference between groups on	Decision	Level	Source
Achievement			
Test I	reject**	.025**	$E-\frac{1}{2}(C_1+C_2), E-C_2$
Test II	fail to reject		
Test III	reject**	.01**	$E-\frac{1}{2}(C_1+C_2), E-C_1, E-C_2$
Exam	fail to reject		
Test I x older/younger	fail to reject		
Test II x older/younger	fail to reject		
Test III x older/younger	reject**	.03**	older-younger
Exam x older/younger	reject**	.04**	older-younger
Test II x lapse/direct	reject**	.05**	lapse-direct
Attitude			
general	reject**	.05**	$E-\frac{1}{2}(C_1+C_2)$
course	reject**	.03**	$E-\frac{1}{2}(C_1+C_2)$
total	reject**	.05**	$E-\frac{1}{2}(C_1+C_2)$
teaching	fail to reject		
modern	fail to reject		
school	fail to reject		
method	fail to reject		

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

As early as 1961 (and again in 1966) the Committee on the Undergraduate Program in Mathematics (CUPM) stated that

> If present trends continue, the better elementary schools may soon be teaching the rudiments of algebra and also some informal geometry. Even in the teaching of arithmetic, sound mathematical training is needed because the teacher's understanding affects his views and attitudes; and in the classroom, the views and attitudes of the teacher are crucial. To an undertrained teacher, arithmetic is merely a collection of mechanical processes and is regarded with boredom, or dislike, or even fear. It is not surprising that, in such cases, students react to arithmetic in the same way. Children should be taught arithmetic for meaning and understanding as well as for skills. To teach in this way, a teacher needs to have a kind of training which conveys this understanding and also shows mathematics to be rewarding and worthwhile. The teacher cannot give something which he does not have.[1]

Mathematics through its leaders, literature, studies, conferences, workshops, and education has, within recent years, focused attention on the need to provide prospective elementary school teachers with effective training

[1]Mathematical Association of America, _Recommendations . . . Training of Teachers_, p. 5.

so that the teachers will be able to develop important mathematical skills and concepts in their pupils. These teachers must also have a favorable attitude toward mathematics, if they are not to influence their pupils in an adverse way, toward a subject which is needed so much now, and will be needed even more in the future.

The need for strong effective courses in mathematics for elementary school teachers was stressed by the Committee on the Undergraduate Program in Mathematics in its 1969 report:

> Most prospective elementary teachers are not highly motivated toward scientific and mathematical studies and are apt to be less well prepared than many other students. But if we are to offer to children in the elementary grades a good mathematics program, indeed, if we wish to have the current commercial elementary textbook series well taught, we must manage to persuade these students that mathematics is an important discipline which they can understand. It is imperative that they begin studying the recommended two years of mathematics early, before they have lost too much contact with their earlier training, and in time to strengthen their mathematical backgrounds for other courses in their programs.[1]

In the winter semester of 1970, at Schoolcraft College, a community college in Livonia, Michigan, the seventy-seven students who enrolled in Mathematics 103 became the sample for this study to evaluate the effect of an audio-tutorial laboratory for this course. By random selection the ten o'clock class became the

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[1]Mathematical Association of America, A Transfer Curriculum . . . Two Year Colleges, p. 36.

experimental group and the eight and nine o'clock sections became the control groups.

As prospective elementary school teachers these students would be expected to teach arithmetic. They would also communicate their true attitudes toward arithmetic to their pupils, even when they were attempting to conceal antipathies toward arithmetic. When their pupils sensed the real attitudes of these teachers they would become even more concerned about their arithmetic. In order to avoid this situation it was necessary to develop in the Mathematics 103 students a sense of security and satisfaction in mathematics and to increase the motivation in these students to a level at which they could and would perform to the best of their abilities without, at the same time, developing the extreme anxieties and frustrations which would interfere with learning and achievement. This was, and is, one of the challenges of instructing the mathematics classes for prospective elementary school teachers.

Two methods for improving the mathematical training of these students were recommended:

1. The addition of another course, a Mathematics 104, to follow the current Mathematics 103 in order to increase the breadth of knowledge.

2. The improvement of the learning and achievement in Mathematics 103 in order to increase the depth of knowledge.

Mathematics 104 will be offered in the winter semester of 1971. The remaining source of improving the mathematical training of these students, at the community college level, is, therefore, the improvement of the learning and achievement in the current course.

The questions that we, then, had to solve were:

1. How can we provide the student with the materials and means to study as much as he wants?
2. How can we provide him with assistance at the time that he feels the need for that aid?
3. How can we help the student in Mathematics 103?
4. How can we provide materials and tools for the student to study the content of the course and to feel that he is learning and achieving?
5. How can we arrange to provide the assistance when the student asks for it and to provide a flexible time schedule for studying?

The selection of the audio-tutorial mode of instruction was an attempt to adapt a technique which has been considered successful in the field of biology by leading educators, such as Postlethwait, Novak, and Coladarci, to the requirements of another discipline, mathematics, and especially to Mathematics 103. There has been and is a

great need to improve the amount of learning achieved in Mathematics 103; in the last ten years the amount of mathematics required by the prospective elementary school teacher has more than doubled. The materials (the audio-tapes and slides, and problem sheets) were selected for the laboratory. The students were, thereby, allowed to practice with these tools of instruction before they had their teaching experiences. The cost of the audio-tutorial materials was reasonable and the laboratory was set up in the library listening room. Audio-tapes, slides and problem sheets were easiest to revise, and maintenance of these materials would be relatively simple.

The problem, then, was (1) to provide the opportunity to succeed in learning modern mathematics, (2) to maximize the improvement in the attitude toward mathematics, and (3) to develop a favorable mind set, or readiness, toward the audio-visual techniques of teaching through the student's personal experiences with the techniques.

The purposes of the study were:

1. To compare the effectiveness of the audio-tutorial materials and laboratory with the conventional materials and commercial textbook for the Mathematics 103, the mathematics for prospective elementary school teachers.

2. To compare the effect of the study on the attitudes of these students toward selected aspects of mathematics.

The two control groups attended the usual informal lecture, question and answer, problem-solving and testing sessions, three days a week. The experimental group had the same schedule for two days a week. The third class session was cancelled and the students signed up for at least one hour a week for a laboratory session, where they used audio-tapes, slides, posters, and problem worksheets designed for the laboratory. All materials were interrelated and were prepared to meet the behavioral objectives for the concepts covered in that unit. [Appendix F]. Supplementary aids and devices were also available.

The data for the study were collected in three ways:

1. At the second class session the students filled out the math card which was handed out at the beginning of the hour and collected about fifteen minutes later. [Appendix E].

2. At the end of each unit, in which the three sections covered the same concepts, a test was given on the concepts which had been listed on the review sheet and available one week before the day for the test. The evaluation of these tests was returned to the student at the next session, following completion of the grading

process. At the end of that class hour the tests were collected again for further study and analysis.

3. The attitudinal survey was completed by the students in two parts; the first part was handed out the last day of class and was returned to the desk before the student left the classroom, and the second part, the open ended comments, was handed out at the examination period and was returned with the examination paper. [Appendix C and H].

Analysis of the Data

Analysis of the data has revealed that the audio-tutorial mode of instruction did improve the achievement of the Mathematics 103 students in two of the four tests, and the improvement was enough to raise the average grade for this class above the average grade for either of the control groups. On these two tests the audio-tutorial group achieved a significantly higher mean score than did the combination of the two control groups. When the tests for achievement were crossed with other factors, the factors that showed effect were: (1) age, the older students were more successful on Test III and on the examination, than were the younger students, the $E - 1/2(C_1 + C_2)$ group of older students; and (2) lapse, the "lapse" students who had not entered college directly from high school were the more successful group on Test II.

The attitude survey showed a small improvement in the direction of a more favorable attitude toward mathematics, as defined the difference between attitude in school and attitude at the end of the course, so that the present attitude is more favorable toward mathematics than it was at the beginning of the course.

The significant correlations of attitude and achievement, in the categories of general, course, and total were in the control groups; apparently the experimental group was so involved with the audio-tutorial method that it was not significantly concerned with other aspects of mathematics, or possibly so satisfied to be achieving that the other aspects did not affect them.

All groups favored the audio-tutorial laboratory, and did so in the following order:

1. The experimental group (27 of the 27 students responded), having used the laboratory, favored the audio-tutorial method the most heartily with an average of 4.609 out of 5.000 points.

2. The second control group (24 of the 29 students responded) was decidedly in favor of the audio-tutorial method. The students having more difficulty in learning were apparently of the opinion that this approach would have helped them to improve their achievement and learning. (Some of these students want to take Mathematics 104.)

3. The first control group (8 of the 21 students responded) favored the audio-tutorial method, but more of these students had learned how to study in high school (as can be determined from the Converted Rank in Class scores in Table 10 and the mean score of the group in Table 16). These students preferred an optional laboratory set up so that they could go to the laboratory only if and when they were in need of assistance.

Discussion

The audio-tutorial mode of instruction is an excellent technique for individualizing instruction in order to meet the needs of the student. The adaptation of this method for future use in mathematics classes should be an effective means of improving instruction for many reasons. The first and strongest reason, from the pedagogical standpoint, is the almost unanimous acceptance with which the audio-tutorial method was received by the students. The students who used the instruction presented in this way rated it highly on the survey and recommended it highly, suggesting (1) the future use of the audio-tutorial method in this and other mathematics classes and (2) the extension of time for the laboratory. The students in the control groups expressed their desire for and need of the audio-tutorial method by their ratings and comments in the survey and from the negative correlations between

their achievement and their attitudes toward the laboratory. The students with the poorer grades wanted the laboratory more and rated the laboratory higher.

The second reason for the effectiveness of this method, which is important for these students, is that the improvement of their attitude toward mathematics was effected by the use of the audio-tutorial mode of instruction. That the significantly more favorable attitude toward mathematics of the experimental group was the result of the method of instruction is apparent from the time spent in the laboratory (average time, 2 hours, and maximum time, 14 hours per week) and from the student comments. [See Appendix H].

The audio-tutorial mode of instruction provided flexibility of scheduling and was very effective for those students who wanted to learn and were given the opportunity to use the assigned laboratory. Of the three sections the experimental group seemed to be the class that had most of the unusual problems and emergencies to contend with. The flexibility of the laboratory hours allowed many of these students to make up their regular laboratory hours and to learn the mathematical concepts involved without the need for additional or unusual consideration by the instructor. Learning was achieved despite absences due to such traumatic situations as (1) a serious auto accident, (2) being kicked in the head by a

horse, (3) illness of a son, or (4) a funeral. These situations created tensions for the students involved and the availability of laboratory time and assistance made the adjustments for these problems somewhat easier. The course did not add to their burdens (nor the instructor's) in the way it would have done if they had been in a control group.

The audio-tutorial mode of instruction was instrumental in the significant improvement of achievement by the experimental group in both Test I and Test III. The improvement of achievement was only slightly less than significant in the other two tests as a p of .0580 on the examination would indicate. However, this lack of significant effectiveness was not the result of the audio-tutorial mode. On Unit II two uncontrolled variables were introduced into the study. First the sequence and program for the unit needed further analysis and evaluation. Second, and even more influential to student achievement in this unit, was the necessity to cancel classes for one week.

On the final examination one uncontrolled variable was introduced into the study. The low scores the control group had received on Unit III greatly increased the normal need to achieve, which the students viewed as a challenge. The other two groups had no such motivation.

The audio-tutorial method provided the "older" students an opportunity to spend time in the laboratory, refreshing their previous knowledge of mathematics and increasing that knowledge to the level they desired to achieve. (College students set their goals and achievement patterns, that is the grades they will settle for.) These students want to achieve but are hesitant about asking for assistance. With this method they do not feel that they are creating any unusual problems for the instructor.

Teachers and administrators will find this audio-tutorial mode of instruction an effective technique for teaching. Student motivation and interest in the subject matter is much improved and therefore of less concern to the instructor (and administrator).

With this technique the teacher can assist the individual student at the time the student requests aid. The student can repeat the concepts involved, until he feels confident that he knows the concepts.

In the use of the audio-tutorial materials, with this teaching technique, the instructor can insure the student of

1. the opportunity to concentrate on the lesson, without distractions.
2. the repetition of a lesson, or parts of the lesson, as he desires.

3. a multiplicity of materials with which to study.
4. the adjustment of the concepts in the lesson for association, assimilation, and transfer.

One of the advantages of using the audio-tutorial materials is that audio-tutorial materials can be revised and edited item by item, or part by part, or whole units at a time without disrupting the entire program. Another advantage is that the cost of editing the parts of the program can be kept minimal. Also, from time to time new materials can be incorporated into the program. In addition, manipulative devices and inexpensive aids which are appropriate to the behavioral objectives can be utilized in the laboratory. Further, the slides can be revised and easily up-dated, singly or in groups, as needed. Finally, the audio-tapes can be erased and new recordings made on the tapes in order to improve the instruction.

These "tools of the trade" are easy for the students to use. Indeed, the students should become acquainted with these tools, as educational techniques, since their pupils will certainly be aware of them, at least as a means of entertainment.

Conclusions

In General Terms

In the major portion of this study the analyses of the data collected have shown that the following hypotheses are supported:

1. The audio-tutorial mode of instruction will (and did) increase the achievement of the experimental group significantly, as measured by the mean scores of the tests and examination for each group.

2. The audio-tutorial mode of instruction will (and did) improve the student's attitude toward mathematics significantly as measured by their ratings on the attitude scale. [For their comments, see Appendix H].

In Specific Terms

1. The audio-tutorial method of instruction was used effectively to improve the achievement of students in mathematics for elementary school teachers.

2. The audio-tutorial method of instruction was more successful than the conventional teaching techniques for the mathematics for elementary school teachers, as measured by Test III.

3. The audio-tutorial method was significantly better than the average of the conventional techniques as measured by the achievement of these groups of students on Test I.

4. The older students of each group performed better on the achievement tests for Test III and the final examination than did the younger students. After a period of adjustment to studying and to college, the older students apply themselves to their courses and they struggle to achieve.

5. The older students exhibited less tension and frustration in the audio-tutorial group.

6. The group using the audio-tutorial method was better than the average of all three groups and better than the average of the two control groups, when the uncontrolled variables and Test II were removed from the study.

7. Sections in the same course and in the same semester, with characteristics distinctly different from one another are not unusual in education, whether in school or in college. The audio-tutorial method would allow a student to devote as much time as he felt that he needed to study the concepts included in the lesson and the unit. The teacher could devote more time to the student who needed the extra assistance. A range from one hour to fourteen and three-quarter hours per week were spent by the individual student in the laboratory during this study.

8. The student in the laboratory felt that he could progress at his own pace, repeating segments of

the program as he wished. He had assistance available when he wanted it.

Recommendations

The following recommendations for the further testing of the audio-tutorial method of instruction are in order:

1. A replication of the study with a random assignment of the students to the groups to verify the findings of this study.

2. The development of an audio-tutorial laboratory for mathematics courses at the basic level: arithmetic, business arithmetic, algebra, geometry, Mathematics 103 and 104, with a study of the effectiveness of that laboratory.

3. The use of the audio-tutorial method to teach students how to study mathematics, with evaluation of the effectiveness of the laboratory for this use.

4. For practical use, the audio-tutorial method should be used for a laboratory, with the instructor as the resource person. Selected students who have passed the Mathematics 103 and 104 course(s) could have teaching experience by serving as laboratory assistants.

5. If the laboratory of the previous recommendations were set up to include other courses, the student assistant should work with the students for the courses

for which he was qualified. Certainly, the work with a basic arithmetic course would increase his arithmetic efficiency, would show him through personal experience the need for <u>knowing</u> the basic arithmetic facts.

6. The inclusion of other inexpensive audio-visual aids and manipulative devices should be used in further study of this technique.

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APPENDIX A

SMCCMP

MATHEMATICS FOR ELEMENTARY TEACHERS

1. Course Outlines
2. Bibliography
3. Course Descriptions and Textbooks

SMCCMP

Carolyn Re, Chmn.
Harriett Emery
Edward Rathmell

Curriculum for Mathematics for Elementary School Teachers

A. Prerequisite: No algebra prerequisite should be set for the course(s).

B. Philosophy: The tenor of the course should be intuitive, in fact, this intuition should be used to direct the students to their own discoveries of mathematical ideas and principles. The course should constantly refer itself to the topics currently being taught in the elementary school. Various models for the mathematical principles being taught should be presented so that the prospective teacher has several avenues by which she can reach students. Problem solving and the use of mathematical sentences should permeate the course. The course should incorporate discussions of existing supportive materials and the mathematical principles behind each, such as movies, geo-boards, Dienes blocks, Cuisenaire rods and blocks, the abacus, drill sets, computer assisted instruction, and programmed materials. This can be augmented by visitations to elementary schools in the area; by correspondence with schools, or by examination of textual materials being used by the schools.

C. Objectives:

1. The student should develop an awareness, through the experience in this course, that mathematics can be a pleasant experience.
2. The student should learn the basic concepts of mathematics which are in this course outline.
3. The student should become familiar with the structural development of mathematics, such as the development from sets to natural numbers, to integers to rationals.

4. The student should experience and develop an awareness of the processes of inductive, and deductive reasoning and their place in mathematics, especially in problem solving.
5. The student should be able to communicate using current mathematical language, i.e., mathematical symbols and vocabulary.
6. The student should be familiar with the goals, content and sequencing of the elementary mathematics curriculum.
7. The student should be familiar with supportive materials for teaching elementary school mathematics, the mathematical concepts they illustrate, and their effectiveness.

Course Outlines

Mathematics for Elementary School Teachers

This list of concepts is intended to be the content of the Mathematics for Elementary School Teachers' courses. The following order of presentation is suggested.

I. Patterns - This concept is to be introduced and then to be used recurrently throughout the course.

   A. Arithmetic

   B. Geometric

   C. Special

      1. Fibonacci numbers

      2. Pascal triangle

   D. Sequences

      1. Arithmetic

      2. Geometric

   E. Series

      1. Arithmetic

      2. Geometric

      3. "Square" numbers, numbers which can be put in square array, such as. ..   ...
         ..   ...
         ...

      4. "Triangular" numbers, numbers which can be put in a triangular array, such as . .   .
         . .   . .
         . . .

   F. Number line

*II. Sets

   A. Well-defined sets

   B. Members of sets

   C. Set builder notation (use of variables)

   D. Empty set and universal set

   E. Infinite and finite sets

*absolute must

F. Relationship between sets
   1. Equal
   2. Subset
   3. Disjoint sets
   4. Overlapping sets

G. Partitions of sets

H. Operations on sets
   1. Unions
   2. Intersection
   3. Complement and relative complement
   4. Cartesian products
   5. Properties of these operations

I. Cardinality of sets
   1. One-to-one correspondence
   2. Equivalent sets

J. Venn Diagrams

*III. Whole Numbers

A. Numeration systems
   1. Systems without place value, e.g., Egyptians, Roman
   2. Systems with place value
      a. Base 10
      b. Other bases

B. Number theory
   1. Divisibility
   2. Primes, composites
   3. Evens, Odds, naturals
   4. Multiples
   5. Divisors
   6. Factoring
   7. Greatest common divisor
   8. Least common multiples

C. Whole numbers as a system

1. Addition as the cardinality of the union of disjoint sets
2. Multiplication as the cardinality of cartesian product, and as repeated addition
3. Properties of whole numbers with addition and multiplication
    a. Closure
    b. Associative
    c. Commutative
    d. Inverses
    e. Identity
    f. Cancellation
    g. Distributive law
4. Subtraction and division as inverses
5. Graph of wholes x wholes

D. Relations

1. Equalities
2. Inequalities and order of numbers

*IV. Algorithms

A. Definition

B. Proof of algorithms

1. Addition
2. Subtraction
3. Multiplication
4. Division

C. Algorithms - examples:

1. Scratch methods of 4 operations
2. Lattice method
3. Lightning method
4. Shortcuts based on:
    a. $(a + b)(a - b)$
    b. $(a + b)^2$
    c. $(10a + 5)^2$
5. Distributive law for multiplying $a(b + c) = ab + ac$

References: Ward and Hardgroves, <u>Modern Elementary Math</u>, Second Printing, 1964. pp.155-160.

D. Operations in any non-decimal bases

1. Add
2. Subtract
3. Multiply
4. Divide

} Charts for an operation are supplied to students

*V. Positive Rationals

A. Definition as $\{\frac{a}{b} | a,b \varepsilon W;\ b \neq 0\}$ or $\{\frac{a}{b} | a \varepsilon W;\ b \varepsilon N\}$

B. Vocabulary of rationals

1. Improper
2. Proper
3. Mixed

C. Ordered pairs

D. Partitions of discrete sets, regions, and number line

E. Renaming equal fractions

F. Ordering by using $\frac{a}{b}$ related to $\frac{c}{d}$ as ad is related to bc

G. Operations and algorithms

H. Renaming and operating on numerators as whole numbers

I. Properties of operations and inverse operations - division; multiplicative inverses now exist

J. Complex fractions

K. Subsets

1. B_b as a subset of F
2. $B_b = \{\frac{a}{b^x} | a,x \varepsilon W;\ b \varepsilon N\}$
3. $B_1 = W$
4. B_{10} = decimal fractions

L. Decimal fractions

1. Relating decimals and fractions, including conversions
2. Estimation, rounding off, and order
3. Algorithms for decimals
4. Per cent
5. Problem solving

*VI. Integers

A. Definition

{. . . , -3, -2, -1, 0, 1, 2, 3, . . .}

B. Number line extended to I

C. Operations on integers

1. Algorithms, using those on W
2. Properties, using those on W

D. Models for operations on integers

1. Vectors
2. Patterns
3. Madison Project Postman Stories and High in the Sky, in Arithmetic Teacher; PLUS (a book on techniques that work.)

VII. Reals and Rationals

A. Define as all numbers with an infinite decimal expansion

B. Find a pattern that would establish a non-repeating decimal

C. Prove $\sqrt{2}$ is irrational by the usual method and by using the Fundamental Theorem of Arithmetic, i.e., Unique Factorization Theorem

D. Operations with radicals

E. Properties of the real number system

F. Estimating radicals by interpolation

VIII. Systems and Their Structure

A. Definition

B. Operations

1. Tables
2. Charts
3. Properties

C. Examples

1. Modular arithmetic
2. Rectangle symmetry
3. Symmetry of equi-lateral triangle
4. Peg Board permutations

IX. Problem Solving and Mathematical Models

A. Word problems
B. Mathematical sentences
C. Linear equations
D. Order of operations
E. Use of formulas, examples:
    1. Interest
    2. Perimeter
    3. Area
    4. Volume
    5. Work
    6. Distance
F. Ratio and proportion
G. Rate pairs

Second Course

X. Logic

A. Inductive and deductive reasoning
B. Mathematical meaning of
    1. Implication statement
    2. Negation
    3. Contrapositive statements
    4. All, every
    5. Some
    6. None

*XI. Geometry and Measure

A. The concepts and definitions of geometric figures
B. Euclidean and topological properties of the common geometric figures
C. Classification of polygons
D. Axioms and proofs of some simple incidence properties

E. Measurement
   1. The concept of measurement as an approximation
   2. Relate measurement to congruence
   3. Length, area, volume, and angle measurement with standard English and metric units
F. Reflections, translations, rotations, symmetries
G. Congruence
H. Constructions
I. Size transformations and similarity
J. Parallels and perpendiculars
K. Angles and circles
L. Optional
   1. Vector geometry
   2. Parallelogram law
   3. Algebra of vectors
   4. Problem solving
   5. Spherical geometry
   6. Differences in Euclidean and spherical geometry
   7. Finite geometry
   8. Duality

*XII. Algebra and Analytic Geometry

A. Addition of polynomials
B. Multiplication of polynomials by a constant
C. Cartesian plane
   1. Vocabulary
      a. Quadrants
      b. Origin
      c. Coordinates
      d. Axes
   2. Graphs of cartesian products
   3. Relations and functions
      a. Definition
      b. Domain and range
      c. Graphs of relations and functions

4. Distances
    a. Directed
    b. Absolute value
    c. Between two points

D. Linear equations
    1. Solution in one variable
    2. Graph of solution on number line
    3. Graph on linear equations in two variables by plotting
    4. Intuitive meaning of m and b in $y = mx + b$
    5. Solution of linear systems by plotting

E. Linear inequalities
    1. Solution in one variable by cut-point method
    2. Graph on number line
    3. Graph of inequality in two variables
    4. Linear programming as an example of inequalities in two variables

F. Graph of higher order equations by plotting
    1. Quadratic equations
    2. Graphing $y = x^3$
    3. $x^2 + y^2 = r^2$ for r = constant
    4. $y = b^x$ for b = constant, $b \neq 1, 0$
    5. Interpreting graph

XIII. Probability

A. Define probability of an event for discrete cases
B. Counting problems
C. Permutations and combinations
D. Independent and mutually exclusive events
E. Problem Solving

XIV. Statistics

A. Compiling and describing data
B. Graphs
C. Mean, median, mode
D. Intuitive presentation of the normal and binomial distributions

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COURSE DESCRIPTIONS AND TEXTBOOKS

Southeastern Michigan Community College Project
Transfer Curriculum in Mathematics

PROGRAM DESCRIPTIONS

Mathematics for Elementary Teachers

Delta: Math 110: Mathematics for Elementary Teachers, 3 hr. credit, 4 hr. contact. Text: Peterson and Hashisaki (Wiley).

Syllabus covers all of Chapters 1-7 and work on real numbers in Chapter 8 is discussed quickly.

Henry Ford: Math 30: Mathematics for Elementary Teachers I, 3 hr. credit. Text: Peterson and Hashisaki (Wiley).

In addition to the content in Chapters 1-7, the course includes some work on introductory logic.

Math 31: Mathematics for Elementary Teachers II, 3 hr. credit. Text: McFarland and Lewis, (Heath).

The syllabus includes introductions to number theory, real numbers, non metric and metric geometry, mathematical systems, and solving linear equalities and inequalities.

Highland Park: Math 231: Mathematics for Elementary Teachers, 3 hr. credit. Text: Ward and Hardgrove (Addison Wesley).

The syllabus includes history of numerals, bases, sets, the whole and fractional numbers, fundamental operations and their properties, algorithms, and number theory.

Math 232: Mathematics for Elementary Teachers, 3 hr. credit. Text: Ward and Hardgrove, (Addison Wesley).

The syllabus includes integers, real numbers and their properties, algebra, graphing, informal geometry and informal topology.

Jackson: Math 111: Foundations of Mathematics, 3 hr. credit. Text: Peterson and Hashisaki (Wiley).

The syllabus includes the text material through the rational numbers (Chapter 7) and selected topics concerning the real numbers.

Macomb: Math 115: (No course title available), 3 hr. credit. Text: Wheeler (Brooks/Cole).

The syllabus includes elementary logic, sets, natural and whole numbers, operations of these numbers, equalities and inequalities, integers and operations, numeration systems, and the rational numbers.

Math 116: (No course title available), 3 hr. credit. Text: Wheeler, (Brooks/Cole).

The syllabus includes decimal numeration, real numbers, number theory, modular arithmetic, elementary algebra, graphing, geometry both metric and non metric.

Oakland: Math 251: Mathematics for Elementary Teachers I, 3 hr. credit. Text: Wheeler (Brooks/Cole -- Fundamental College Mathematics).

The syllabus includes sets, whole numbers, numeration systems, integers, number theory, fractions and rational numbers, and decimals and real numbers. Non metric geometry is optional. A supplementary booklet exists which contains performance objectives for the course and also study assignments, hints and time limits.

St. Clair: Math 110: Foundations of Mathematics, 3 hr. credit. Text: Brumfiel (Addison Wesley).

Schoolcraft: Math 103: Mathematics for Elementary Teachers, 3 hr. credit. Text: Ward and Hardgrove (Addison Wesley).

The syllabus includes sets, whole numbers, numeration, binary operations, algarithms, informal geometry, fractions, algebra and problem solving, patterns in mathematics. (Note: This syllabus may change in 1970-71).

Washtenaw: Math 107: Principles of Elementary Mathematics, 3 hr. credit. Text:

Course not now taught.

Flint: Math 261: Mathematics for Elementary School Teachers, 3 hr. credit. Text: Peterson and Hashisaki.

The syllabus includes numeration, sets, relations, and the systems of the whole numbers, the integers, the rationals, and the reals. Chapters 1-8 are covered.

APPENDIX B

ELEMENTARY ARITHMETIC TEXTBOOKS USED IN 1967 IN SCHOOLCRAFT COLLEGE DISTRICT

Textbooks Used in 1967 in Elementary Arithmetic Classes

in the Five Public School Districts within Schoolcraft College District

	Elementary Grades	
Clarenceville	K - 8 Holt, Rinehart, & Winston — text only	
Garden City	K - 6 Science Research Associates — text only	7 - 8 American Book — text only
Livonia	K - 6 Addison-Wesley — text	7 - 8 (regular) Holt, Rinehart & Winston — text
Livonia	K - 6 Science Research Associates — teacher supplement	
Livonia	K - 6 Workbooks	7 - 8 (slow) Addison-Wesley — text
Livonia	4 - 6 (enrichment) Spooner, Lola May	
Northville	K - 5 Addison-Wesley — text	6 - 8 Laidlaw Series — text
Plymouth	K - 8 Science Research Associates — text only	

APPENDIX C

ATTITUDINAL SURVEY

SURVEY

Name ____________________

The Mathematics Department of Schoolcraft College asks your cooperation in filling out this survey so that we may improve this course. This survey will be kept confidential and the data collected will be compiled and studied only after the semester grades have been turned in to the registrar. (Your name is needed for research purposes only.)

Directions: Please write your name in the upper right hand corner.

Each of the statements on this survey expresses a feeling which a person has toward mathematics. You are to express on a five-point scale, the extent of agreement between the feeling expressed in each statement and your own feeling. The five points of the scale are:

Always (A), Often (O), Sometimes (S), Rarely (R), and Never (N).

You are to put an X in the block for the letter that best indicates how closely you agree with the feeling expressed in the statement as it concerns you.

	A	O	S	R	N
1. I am eager to study my mathematics lesson because there is such a feeling of satisfaction in completing each assignment and knowing it is done correctly.					
*2. In mathematics classes at school (not college) I tried and tried, but I needed help to complete my mathematics assignments.					

---

rating
* 1→5
no * 5→1

		A	O	S	R	N
*3.	I dislike mathematics and I resent the time I have had to devote to this mathematics course.					
*4.	Of all my classes in grade school and high school, I dreaded mathematics the most. The class hour seemed to drag on forever.					
*5.	Mathematics makes me feel depressed and uncertain; I put off studying it as long as I can.					
*6.	I needed more help than I could get.					
7.	My parents didn't like mathematics and I don't like mathematics; I guess it runs in the family.					
8.	When I apply for my teaching assignment, I will request a position which includes teaching arithmetic.					
9.	Having the answers to the problems increased my understanding and helped in finding errors.					
*10.	I will be glad to get through this required course.					
11.	I liked the textbook; I could study at home whenever I wanted.					
*12.	A mathematics problem is always an incomprehensible jumble of words and numbers which I cannot translate into symbols and numerals.					
*13.	Learning "modern" mathematics has been more difficult for me than learning the other mathematics.					
*14.	It was hard to keep up with the class; I needed more time to assimilate the required concepts.					
15.	In high school I enjoyed my mathematics classes; I was sorry to hear the bell ring.					

		A	O	S	R	N
16.	The teaching techniques (lecture, discussion, test, etc.) used in this class made the material meaningful and clear.					
17.	I have enjoyed this course, but I still feel the need for more mathematics to be a good elementary teacher.					
*18.	I had "modern" mathematics in high school and this course has been a repetition and a waste of time; I have learned nothing new.					
19.	I like mathematics; therefore, I finish my other studies first, in order to devote my full attention to mathematics.					
20.	I have enjoyed this mathematics class; the time seemed to fly by when I was studying my next assignment.					
*21.	I am frustrated by mathematics; I will not accept any position which includes teaching arithmetic.					
22.	I like mathematics; I feel I will be able to teach arithmetic in elementary school.					
23.	I like to explain solutions to mathematics problems to my classmates.					
24.	I like mathematics more now than I did before taking this course.					
25.	**I enjoyed the laboratory; I couldn't have learned as much by studying at home.					
26.	** I liked the laboratory sessions; I could work at my own rate and I could get help when I needed it.					
*27.	**The laboratory contibuted greatly to my frustration with mathematics. It gave me a lot more to learn.					

Name ________________________

In addition to the above reactions, in the first part of the survey, I would like to have you know that: (Give suggestions, criticism, or comments.)

APPENDIX D

AUDIO-TUTORIAL [BIOLOGY 101] AT

SCHOOLCRAFT COLLEGE

by

Gordon G. Snyder

History

Audio-Tutorial (A.T.) at Schoolcraft College began in the fall of 1966 with an examination of Dr. S. N. Postlethwait's A.T. botany laboratory at Purdue University. Following that examination and after hours of discussions and visits to other A.T. laboratories in the area, the biology division decided to devise an A.T. approach for our general biology course. The division spent the remainder of that year in the general development of the procedures and materials for a pilot program. During the summer of 1967, two instructors were employed and charged with the specific development and production of materials for the pilot program. This included the writing of scripts, a student guide, and the construction of four booths and development of the laboratory area, which was a corner of a small greenhouse adjoining one of our traditional laboratories.

The pilot programs involved two classes (one each semester) of 24 students. Weekly divisional meetings resulted in a constant evaluation of the program and revisions of it as it progressed.

A final evaluation of the pilot program lead us to the conclusion that all the general biology students would benefit from being taught by an A.T. approach, and that a total A.T.

program should be developed. Two instructors were again employed for the summer of 1968 to complete the development of the total program.

Audio-Tutorial Today

Presently, our Biology 101 course has three components: The combined lecture, the open laboratory, and the seminar quiz.

The combined lecture is a scheduled one hour session for approximately 90 students. There are four combined lectures each given by a different instructor. These lectures provide the opportunity for orientation, guest speakers, long films, exams and other aspects of a biology course that would be best suited to large group meetings. Major exams are also given during this time. The combined lectures are held on Mondays.

The open laboratory is the only non-scheduled portion of the course. The laboratory is equipped with 29 individual booths each containing a tape-recorder, microscope and other appropriate equipment. Materials that do not lend themselves for booth activities are placed in peripheral demonstration areas. The student checks into the open lab with the help of a student receptionist. The open lab is available from 7:00 a.m. to 5:00 p.m. Monday through Thursday, and students may visit it as frequently and stay as long as they desire. Our experience has shown that the hours of greatest utilization occur from 9:00 a.m. to 3:00 p.m. We also know that

the first week involves a settling process; thus, students will at first encounter some difficulties in getting into the open lab when they so desire. After the first week, however, routines are well established and further difficulties are practically nonexistent. Information on booth availability is given to the students each week which helps them to determine their own schedules for the open lab.

The learning sequence is on tape and includes lectures, laboratory exercises and experiments, readings from scientific journals, and textbook assignments. Periodically, the student will be directed to demonstration areas for observation of super 8 mm film loops, charts, living specimens, and to carry out exercises and perform experiments.

The Burgess A.T. Systems tape recorders are under the individual control of the student, and he may repeat any portion of the learning sequence. One booth is available for make-up work in case a student should (because of illness or death in the family) miss a portion of a weekly learning sequence.

A full-time biology instructor (any of 9 in our department) is always available in the open lab for tutoring students on a one-to-one basis. Students are also able to interact with each other in demonstration areas, booths, and in the A.T. reading room, which is available directly off the open lab. It contains numerous reference materials and is suitable for informal interactions between students and instructors.

Students are guided through the weekly learning sequence by focusing their attention on objectives. Each learning sequence has been divided into several objectives which are given to the students. The objectives state the goals of the weekly learning sequence by clarifying what the student should be able to do and how he is to do it. The following is an example:

Objective 1. Gain an understanding of the problems of the regulation of body fluids.

By listening to the tape, reading pages 446-447 of your textbook, viewing the film loop, and asking the instructors for assistance, you should be able to:

1. List 7 problems in the regulation of body fluids.
2. Define plasmolysis.

Evidence of your knowledge of this objective will be obtained from the seminar quiz and major exams given by your instructor.

Other materials are also provided including a list of all the terms used on the tape. This word list is placed in the booth for easy reference while the student uses the tape. A student guide is also utilized which contains drawings, charts, and outlines of exercises and experiments. All tapes are made by one instructor.

Seminar quizes are held during an hour's scheduled session on Friday and/or Monday. An instructor's Monday combined lecture sessions are divided into five quiz sessions containing 14-18 students. Instructors gear these sessions

to meet the needs of their students. Forty percent of the student's final grade will come from the instructor's evaluation of the student during the seminar quiz.

In conclusion, I have prepared a chart (fig. 1) which reflects the progression of ideas which were employed in the development of our present day Audio-Tutorial approach.

THE DEVELOPMENT OF A.T. GENERAL BIOLOGY AT SCHOOLCRAFT COLLEGE

Year and Semester of Operation	Approx. Total No. of Students	No. of Stations	Total Hours of Open Lab
1967 Fall	24	4	[1] 22
1968 Winter	24	4	22
1968 Fall	317	29	57
1969 Winter	189	29	47
1969 Fall	320	29	57
1970 Winter	240	29	47

Staff		Weekly Schedule: Lecture	Weekly Schedule: Quiz	Significant Aspects
1967 Fall	1 [2] Full time Instructor 5 [3] Part time Instructors	1 hr. scheduled	1/2 hr. [4] oral seminar quiz	Pilot Program, 1 class only.
1968 Winter	1 Full time Instructor 5 Part time Instructors	1 hr. scheduled	1/2 hr. oral seminar quiz	Pilot Program, 1 class only. Considerable experimentation with quizes.
1968 Fall	2 Full time Instructors 6 Part time Instructors	1 hr. scheduled	1/2 hr. oral seminar quiz	1st semester of full program - all classes. One instructor gives all combined lectures-quizes divided among all instructors.
1969 Winter	1 Full time Instructor 6 Part time Instructors	1 hr. scheduled 2 combined lectures	1 hour [5] seminar quiz	Quiz increased to 1 hour. Oral portion eliminated.
1969 Fall	4 Full time Instructors 5 Part time Instructors	1 hr. scheduled 4 combined lectures	1 hour seminar quiz	An instructor gives only 1 of the combined lectures. Those students are divided into 5 seminar quizes which are given by the same instructor.
1970 Winter	4 Full time Instructors 5 Part time Instructors	1 hr. scheduled 4 combined lectures	1 hour seminar quiz	" " " " " " " " "

(Fig. 1)

1. All instructors in our division donated their time to maintain the open lab for 22 hrs/week.

2. The term <u>full time instructor</u> does not designate academic rank, but rather one member of our staff whose major course load is in the A.T. general biology course.

3. Donates a staff member whose major load is other than general biology, although some portion of time is spent in the open lab.

4. The students orally demonstrate their knowledge of weekly objectives.

5. The students discuss problems and ask questions concerning weekly units. The instructor also quizes them (usually written) on the objectives of that unit.

APPENDIX E

MATH CARD

MATH CARD

Last Name	First	Middle

Address	Street	City

Student No.	Phone No.	Date of Birth

High School	City	Year Graduated

- [ ] Male
- [ ] Female
- [ ] Single
- [ ] Married
- [ ] Freshman
- [ ] Soph.

Senior College Curriculum

Math Placement Test

- [ ] Yes
- [ ] No

H.S. Math	Credit	Grades
Alg. I		
Geom.		
Alg. II		
S. Geom.		
Trig.		
Gen. Math		
Bus. Math		
Other ________		

APPENDIX F

MATERIALS FOR LABORATORY

1. Directions for Tape Recorder
2. Laboratory Card
3. Objectives--Lessons One to Four
4. Student Bibliography

Math 103

Directions for Use of Tape Recorder

I. Threading recorder.

   A. Take reel - place on left spindle, anchor into grooves of reel.

   B. With shiny side of tape facing you - pull out 12" of tape from reel.

   C. Holding end of the tape in your right hand and supporting tape in left hand place tape in slot of playing mechanism.

   D. Place end of tape on right hand reel - wrapping the tape around reel at least once to prevent slipping.

II. Turn on tape recorder.

III. Check that speed indicator is set for 3-3/4 rpm.

IV. Put on headset.

V. Turn indicator to play.

VI. Adjust volume to your preference.

VII. Inst. stop may be used for short pauses; for longer span of time stop the machine.

VIII. If you wish to replay a portion of the tape, turn indicator to rewind and allow sufficient time for tape to return to material desired. Turn to stop and then to play.

IX. To leave booth - for short time - (1) turn recorder to stop and turn off motor, (2) take off headset.

X. If difficulty - call instructor.

Laboratory Card

Name ________ MATH 103 Winter, 1970

Lesson	Booth	Date	Time In	Time Out		Lesson	Booth	Date	Time In	Time Out	
1.						8.					
2.						9.					
3.						10.					
4.						11.					
5.						12.					
6.						13.					
7.						14.					

Math 103 - Objectives

H. Emery
Winter, 1970

Lesson One

1. Numbers and numerals.

   a. Recognize a number as an idea or concept as opposed to a numeral as a mathematical symbol.

   b. Use the given number (numeral) in a sentence.

2. Pure or applied mathematics.

   a. Recognize pure mathematics as abstraction - generalization.

   b. Recognize applied as the specific problem.

3. Patterns.

   a. Recognize the arithmetic pattern by (1) describing the rule or (2) giving the next four terms.

   b. Recognize the geometric pattern by (1) describing the rule or (2) giving the next four terms.

   c. Recognize the special pattern by (1) describing the rule or (2) giving the next four terms.

4. Differentiate between the types of patterns - to use the type of pattern by

   a. Supplying a missing term within a sequence.

   b. Continuing the next four terms of a sequence.

5. Series.

   a. Continue a series by adding four more terms to a given series.

   b. Distinguish between a sequence and a series.

   c. Recognize the relation between a sequence and a series.

   d. Use pattern to continue a harmonic sequence.

Math 103 Objectives H. Emery

Lesson Two

Sets

1. To define a set

    a. by listing or enumerating its elements

        (1) order is not important

        (2) elements are listed only once

    b. by describing a property or stating a rule for selecting the members of the set

2. To identify, from a given set:

    a. a subset of the given set

    b. a proper subset of the given set

    c. all subsets of the given set

    d. the total number of subsets of a given set

3. To recognize

    a. equal sets

    b. unequal sets

4. To identify

    a. finite sets as those whose elements can be listed and counted

    b. infinite sets - elements cannot be listed or counted

5. To recognize

    a. variables as elements that vary or change within a given situation

b. constants as elements that do not change in a given situation, and are in two classes

(1) never changes: 2, π, e, i

(2) change from one situation to another:

$ax^2 + bx + c = 0$;
a, b, c are constants

6. To use the proper notation for the concepts listed above

7. To draw the Venn diagrams for these relationships

Lesson Three

Sets (Cont'd.)

1. To form the intersection of two or more given sets by defining the resulting set:

   a. listing elements

   b. stating rule

2. To form the union of two or more given sets

   a. listing elements

   b. stating rule

3. To identify possible universal sets for a given situation, and to select the better (or best) universal sets

4. To identify the sets: W, N, O, E.

5. To recognize the null or empty set:

   a. as a set

   b. as a subset of a set

   c. $n(\emptyset) = 0$

6. To identify, or form, a complement:

   a. of a set

   b. of an intersection of sets

   c. of a union of sets

7. To classify elements of a set into sets which are mutually exhaustive and exclusive

8. To use the proper notation for the concepts listed above

9. To draw Venn diagrams for these relationships

Lesson Four

Sets (Cont'd.)

1. To identify an ordered set of numbers

   a. single elements

   b. ordered pairs

2. To form the Cartesian product of two given sets

   a. by listing the ordered pairs

   b. by stating the rule for determining the ordered pairs

3. To put given sets in one to one correspondence

4. To determine the number of elements in a given set by putting it in one to one correspondence with a counting set

5. To count the elements of a finite set

6. To identify equivalent sets

7. To identify the relationships of sets

    a. reflexive

    b. symmetric

    c. transitive

8. to use proper notation for the concepts listed above

9. To draw Venn, or Euler, diagrams of all these relationships

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APPENDIX G

SEQUENCING MATERIALS

1. Selected Concepts and Principles for Units I, II, and III[1]
2. Chaining of Concepts-Interrelations
3. Topic for a Lesson
4. Task Analysis[2]

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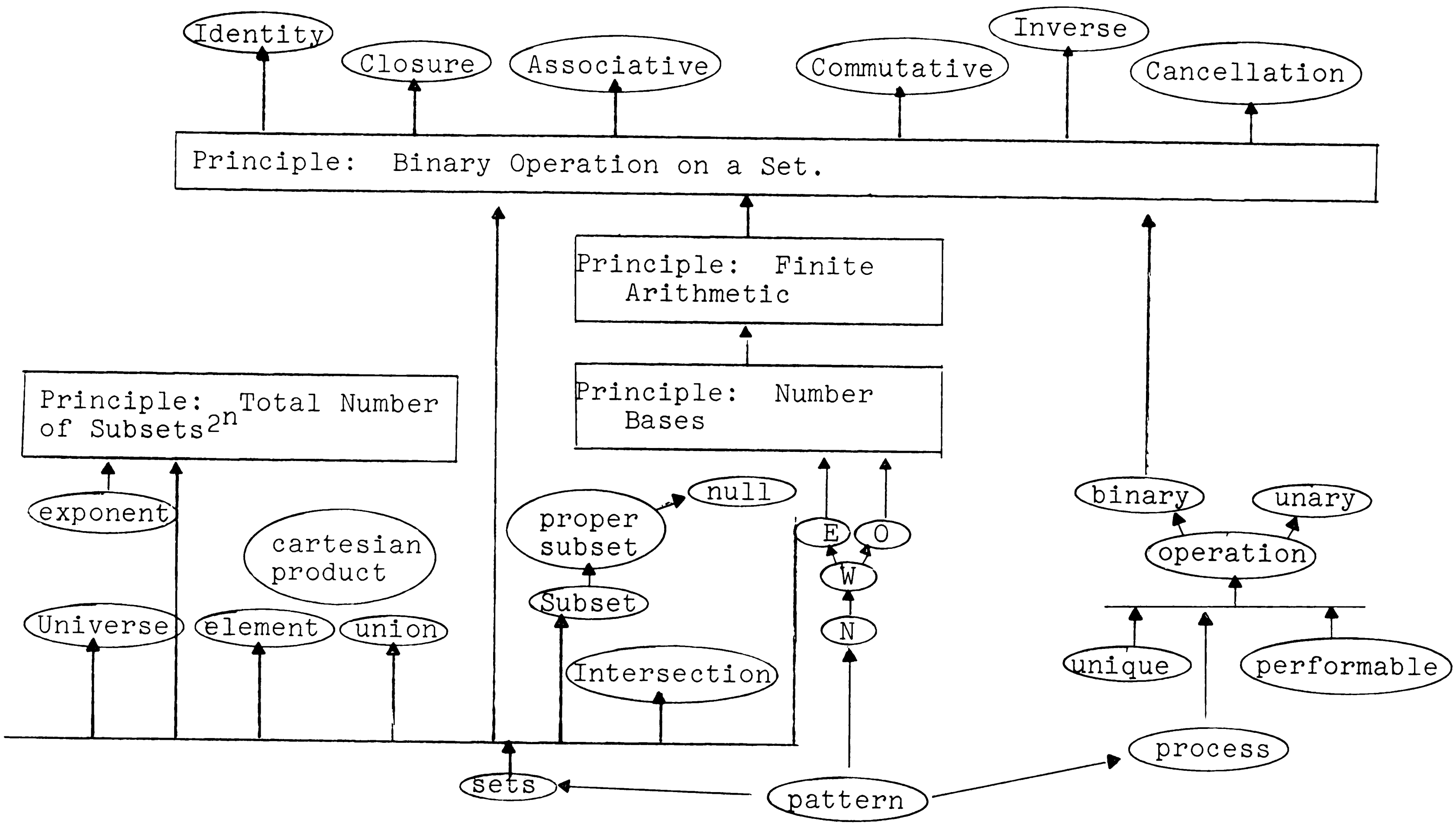
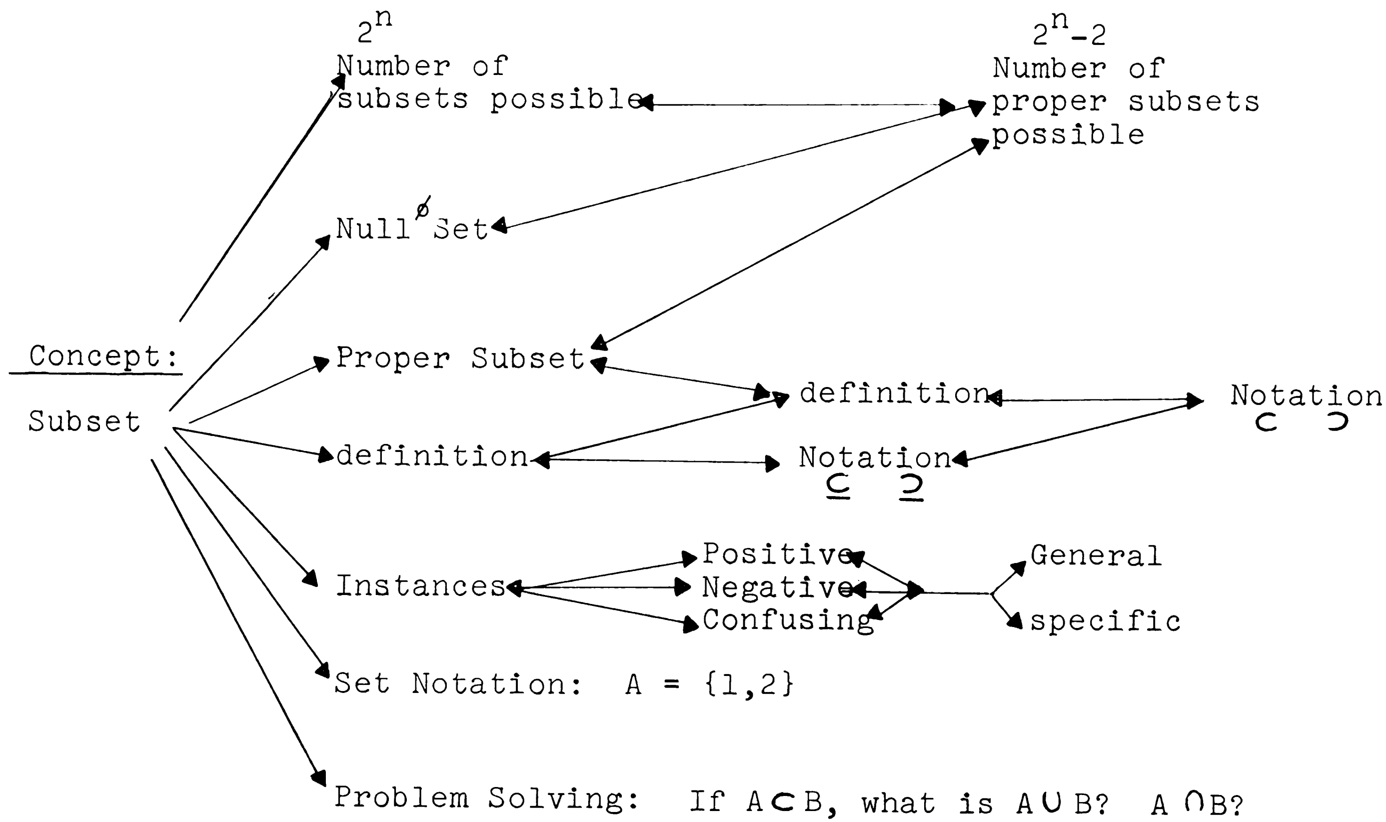
[1]Robert M. Gagné, The Conditions of Learning, (New York: Holt, Rinehart and Winston, Incorporated, 1965), p. 181.

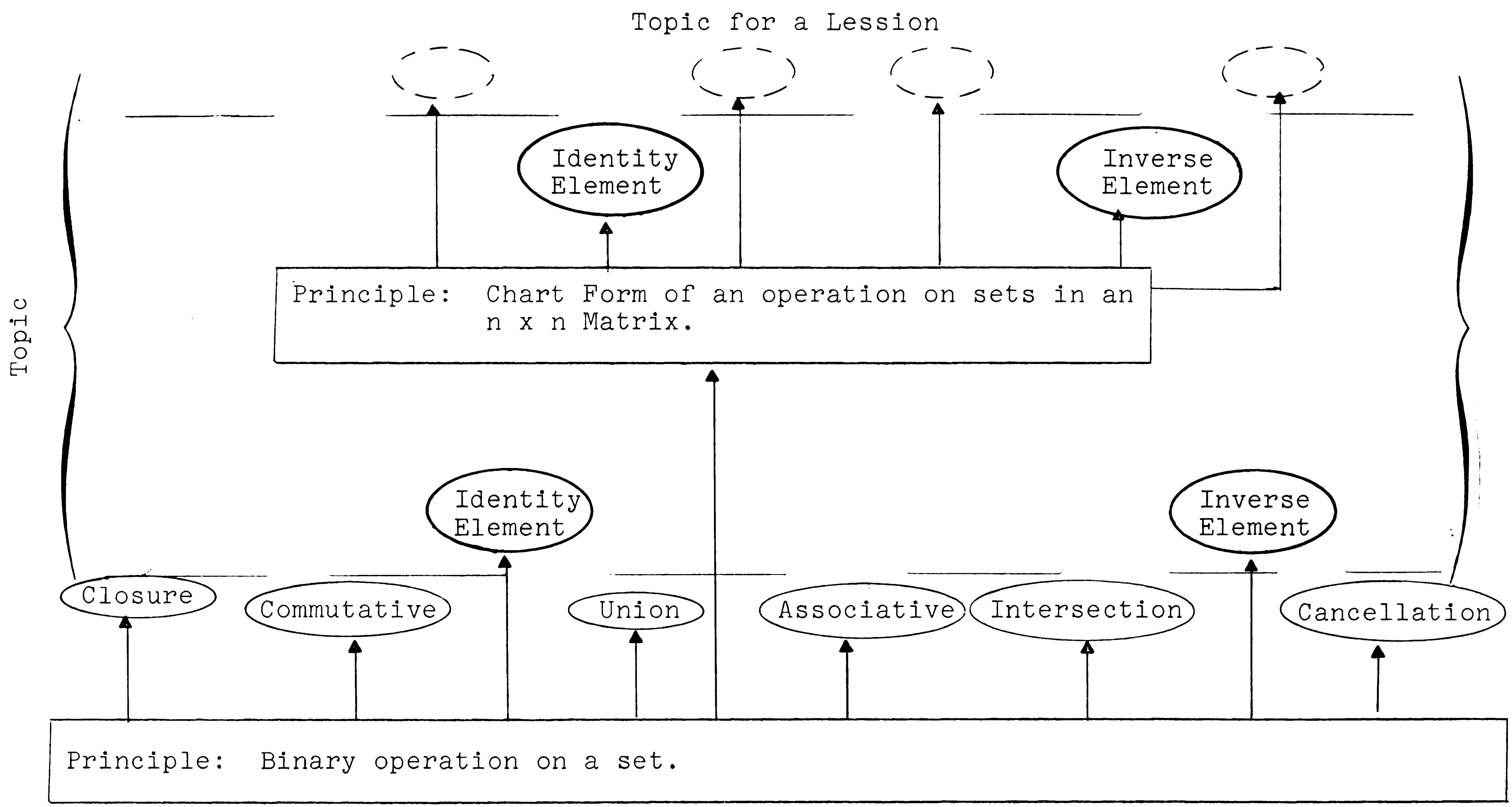
[2]Education 411 and 811.

Selected Concepts and Principles
from Units I, II, and III



Chaining of Concepts
(Interrelations)
Chart III

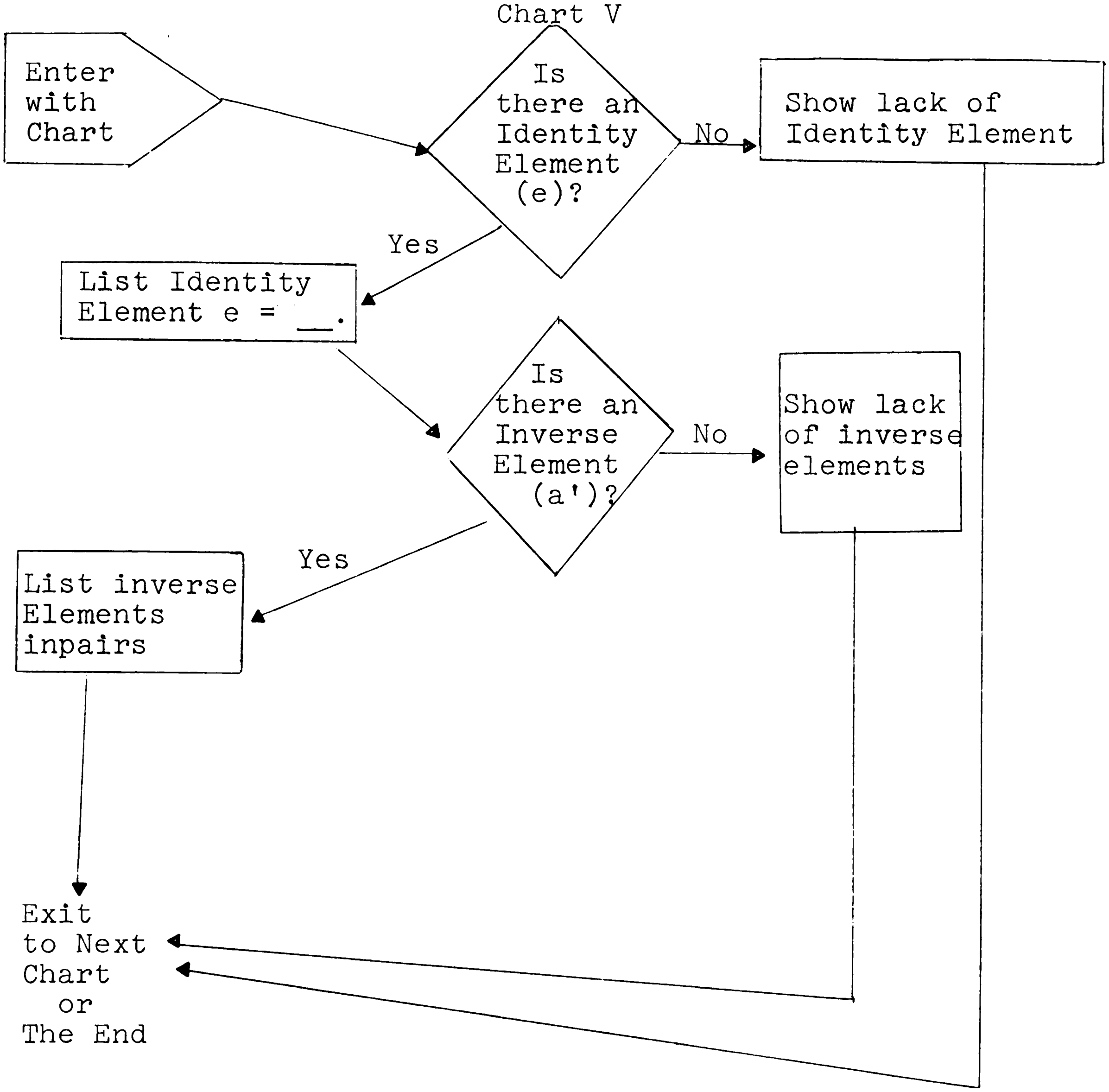



Topic for a Lession
Topic
Identity Element
Inverse Element
Principle: Chart Form of an operation on sets in an n x n Matrix.
Identity Element
Inverse Element
Closure
Commutative
Union
Associative
Intersection
Cancellation
Principle: Binary operation on a set.

Gagné, p. 181.

Task Analysis

Chart V



APPENDIX H

STUDENT RESPONSES FOR OPEN-ENDED COMMENT

STUDENT COMMENTS

by

Groups

Group I: Control

1. First of all, I thought a lab would have suited this class well. It would have been a great help. This comment resulted from the fact that sometimes if you missed class or did not understand a certain concept, it might not have been enough to explain it a second time in class. Or some students might have wanted to persue a certain technique, but it was not a requirement of the class to know that technique, and not enough time to explain it for those who understood it.

Second, I thought the class went too slow, but that's only an opinion.

2. Math does nothing more than frustrate me, I would rather just say thanks for the reminder and goodby.

3. I think that we spent too much time on the first few chapters because we had to go pretty fast through the last ones. Other than that I enjoyed the class and learned some new concepts. (Shortcut mult., especially!)

4. I have learned a great deal from you intent teachings and now have a better understanding of math.

I enjoyed the class.

5. You have a very interesting class. You present the material in a very interesting way. Math has always been my downfall in school. I guess it's just not one of my gifts, but I do try. I appreciate everything you've taught me: which is quite a lot.

6. On the whole this class was very informative and worthwhile. I learned a lot by the way you taught. Also very helpful were the ideas you would present on ways to teach these new methods to children and the ways teaching math can be made into a "game" which would be

much more advantageous to the child, since children do love games.

I don't feel that the text was of that much value to me (except for checking a couple of things). I learned a lot more by listening to the lectures in class.

My honest opinion is that basically I don't think you should change any of your teaching habits. If students would learn to apply themselves (which I am guilty of sometimes too) instead of griping about classes, I'm sure they would see more value in the way you are teaching.

7. I was, at first, very frightened about taking math, because I had so much trouble with it in high school.

I did, though think I learned more from this one course with you than I think I have from all the other ones I have ever taken. You explain everything very well, and I really enjoyed your teaching. I hope that someday I can get it across to my elementary children as well as you reached me.

Your examples were great and they made it much easier to see and to understand. You are a very good teacher and I can see how children would have loved you.

I think I would have enjoyed it more if it wasn't at 8:00 in the morning!

The book was also very good and it helped explain the information while I was at home.

The home tests you gave were good, because I sure needed the review if I'm ever to be able to explain it to children.

You helped me to learn a lot, even though some of my grades didn't show it. Thank you!

8. Sometimes, Miss Emery, it wasn't very clear what you were trying to get through to us. I know you know what you were talking about, but I just couldn't get it. Having you as a teacher is a lot easier than trying to understand the book, though. You sure know what you're talking about.

9. Some of the material that was presented in class was explained in such a way that it was confusing and difficult to understand.

Also directions could have been clearer on tests and take home tests to avoid misunderstanding.

10. When you give both take home tests and class tests there should be more directions as to what kind of answers you wanted. I found that you were not consistent, for instance: on one take home test you marked .60 wrong because it should have been just .6 but yet on an extra credit sheet I got 6/10 marked wrong because it should have been 60/100. One place I should have dropped the zero and the other I shouldn't. How am I supposed to know when I am and when I'm not? I never knew how you wanted numbers expressed (mixed, decimals, fractions) and since you gave no directions I got a perfectly good answer marked wrong because it should have been expressed another way. Be more specific, give directions or go over your set of rules at the beginning (which you never did in our class). It would be a great help!

11. My own lack of interest in the class can be the only contributing factor to the poor grades I have been receiving. Being away from math for so long does not prove beneficial, either. Math was never my best subject, but with sufficient effort I realize I am capable of doing well. I only regret that I hadn't looked at it as a <u>not</u> so simple course, when I first enrolled. I am acquainted with several people who take the course with that false and dangerous attitude right from the start! If they could be made to realize that it is not as easy as it looks, perhaps they would take it more seriously and avoid making the mistake that I unfortunately made.

12. I have enjoyed the class, but found the tests kind of hard. I feel the way you taught the class a book wasn't really necessary. I think we should have more quizes over the new things we learned before we have a big test to make sure we know what we are doing.

13. Needs more exchange between teacher and students--this would benefit all the class and teacher in understanding where the problems are.

14. No comment.

15. I have learned much that I hadn't known before, even though I had some knowledge about most of the material. What I had already known I found easy and what was new to me (bases, modulus, charts) were not too hard to pick up. I do feel however that I don't know all of this material well enough to teach it.

16. For me, I feel this course has done some good. Math, being my downfall--as you can probably see, is a struggle. The way in which things have been explained has been good. I feel I understand much more now than when I first started the course.

17. I had a good deal of this material in high school and before--but it's having this class that allows us to use it again before it's completely forgotten about. Unfortunately there were quite a few things I had forgot. It's too bad there is not a continuation of this course. --I think I would take it.

18. I enjoyed the class very much and hope to take part II when given.

The only problem I found, which was confusing, was that the instructor and the book sometimes used different methods.

19. I feel that more time is needed so that the whole book can be covered more thoroughly, also more should to relate it closer to the principles by the teacher in the elementary classroom. I liked the class it is very interesting but I feel I in particular needed more time to grasp some of the concepts presented.

20. I feel we should have had more participation on behalf of the class, like small groups, etc. to discuss difficulties rather than straight lecturing.

Group II: Control

1. Math has never been a good subject for me. I guess I made myself hate it when I was little because I always put it off till last. I still do it now. I thought that if I took another math course, it would make me like the class more, but it didn't help. I did learn more about math though. But I think the lab idea is a good one.

2. I feel I've really learned from this class; however, I am sorry there is no continuating class to follow. Until this year math was just another subject but somehow you've made me realize how much fun it can be. I hope some day I can do the same for my students.

3. Part of my "essay" is on the other sheets. I like the idea of a lab--it's ideal for people like me.

[From the other paper] I've always had a hard time with math in grade school and high school. I've always enjoyed geometry (it seems to make more sense). At the present time I feel my previous background has been poor and I will not teach it until I've become more skilled in it. I feel I would cheat my students if I did. I know the exact feeling some of the nuns I had in grade school knew less than some of the brighter kids. Thank you.

4. I enjoyed this math class and did better than I expected to do. Everything was clearly explained and I understood most of the lessons right away. Thank you for making math more enjoyable.

5. I enjoyed your class and learned and refreshed much.

There were a few times such as in bases that you went a little too fast for me as bases were entirely new to me.

A lab course would have been very beneficial in my case.

6. (1) Be more demanding on requiring homework.
(2) Allow no one in after attendance is taken.

(a) Class taught well.

7. I was miserable in high school math and it amazes me how well I am doing here. I really and truly enjoy the class and I hope that if I ever have to take another math course it will be one of your classes. You've made math more interesting to me and I would really like to go into it more, if I could get teachers like you. I hope to have you for Math 104, if I can take it when it's given.

8. I was told my best bet would be to take this math course over Biology. I had to have one or the other. However I do not resent the fact that I made this choice. I did learn something, however minimal it may have been (and the little it is, is through only my own fault.)

Science and math are not my strong points so I'm glad this course is over, but I did enjoy the class while I had it.

9. The class was taught very well, I'm just sorry I didn't benefit from it like I should have. My attitude

towards math is my problem. But the class is one from which a lot is to be learned and you seemed to have taught it in a way which makes the hardest math seem a little easier. Thanks.

10. In past years I have disliked math but this was different. I didn't love it, but I didn't dislike it as much as other math classes.

11. I have a very difficult time in understanding math. It takes me quite a bit of studying to comprehend math. If we had a lab like the Biology department, I think I could have understood the math better. If I have something visual I do better--abstracts escape me.

I enjoyed the class but I still feel uncertain, depressed and undecided what I've learned or accomplished. I don't feel I've learned anything that I can apply to teaching.

When I was told that it was elementary math I expected I guess a lot of children's math, like from 1st grade to 6th.

12. The course was O.K.

13. -- I enjoyed the class extremely--not totally because I like math, but because it was well taught.

-- A student can't help but love math, with a teacher who loves her field, and devotes more time to the class and to each student.

P.S. I really learned a lot.

14. More hand out sheets for practice because I needed extra practice on certain parts.

15. I have learned quite a lot more from this class about the basic principles of math. I liked the text and I preferred the class without any use of laboratory.

16. I think you should have spent a little more time on certain things. I think the idea of a laboratory was a good one. It would give a person like myself whose not very good in mathematics someplace to go for additional help.

I feel you should try to make the class more interesting. I found it terribly boring (but then I find math terribly boring).

17. No comment.

18. I think a new textbook should be used to replace the one we now use.

19. I felt that this course was very interesting & that it was fairly easy to understand. With the high school background I have had in math I was able to understand most of the assignments using my background in math along with the new ways being taught.

To me, this course was beneficial & I would like to teach a math course using the techniques we used in Math 103. If I had a chance to teach math I wouldn't turn it down, but the courses I am taking now I hope to go into Art Education.

The course was well taught, the work was easy to understand, & I really enjoyed the class.

20. For the most part the material covered was already taught to me when I was in high school. I was never good in math at all, and this was proven by the fact that I did poorly on all the home tests, which were a review of what we learned years ago. I benefited a lot from this course but am still too weak to ever attempt to teach it to elementary school children. I have little confidence when it comes to math classes, & I therefore cannot picture myself ever excelling in it to the point where I would enjoy teaching it to others. After being away from math for nearly 2 years I was surprised to find myself taking an interest in it.

21. The class has too few exercises in showing how each operation works. I found the ditto sheets very helpful. The class moved too fast on algorithms.

22. I think extra problems in each type of operation would be helpful. Perhaps a workbook could be used along with the text, especially if one finds extra practice is needed. Also, I believe testing more often would help clear up any misunderstandings one might have about the work.

23. I think a math laboratory would really help the students, especially if they were having trouble with the work.

24. My biggest problem was lack of background in math, it's been 10 years since I had any courses in math.

Something like a lab would have been quite helpful I think to brush up and go over my problems.

25. I would highly recommend the math work shop; working on similar problems would have been a great help.

26. I feel I could have benefited from a math lab.

27. I would suggest a whole year course of math. That would better prepare one for teaching.

Group III: Experimental (Audio-Tutorial)

1. I have gained a lot of new elementary mathematical knowledge since taking this course. I found the lab work almost essential in learning the work, because I thought the book didn't explain everything well enough or provide useful exercises. Even though the lab work was sometimes long, it was very resourceful.

I also liked the take home quizes because they helped to brush me up in things I needed to be refreshed on.

While doing lab work I'm grateful that you were so patient and always ready to help. (I'm going to remember that when I teach.)

2. The lab is beneficial but the time should be cut down.

3. I thought the textbook was hard to understand. The lab helped greatly. I wish I could have spent more time in the lab.

4. I thought the lab was a great help and it made the class much better.

5. I would like a C.

6. I would just like to say it was an enjoyable class & I think I really learned something.

7. I do think the lab did help, but I was unable to use it more than an hour each week because of the hours I have to work. Therefore, maybe I could have gained more by having the regular class hour.

8. I enjoyed this math class more than any class I had yet taken. However even after studying for a

considerable amount of time I find that I was not prepared for the final. I do not feel at all sure of what I had thought I knew. The test did not seem to be restricted with what we were studying at length. I found several sections, especially parts IX & IV, confusing. I feel that there was much we did not cover thoroughly enough in class that was part of this exam.

9. As I said in the first section of the survey, I believe that the class time was of more help to me than was the lab.

10. I believe that the lab was very helpful. I think it would be a good idea to install more tape recorders and slide viewers so that instead of having only one hour a week to come in. Each pupil could feel free to come in whatever day is convenient and spend as much time as he needs. Most of the exercises could not be done in an hour and with more freedom I believe it would enable everyone to learn at a speed at which he is capable.

It also would have been helpful in studying for tests if we had our own papers and tests to refer back to.

11. I enjoyed lab time very much--it helped me quite a bit. Many concepts finally became clear to me in your classes in lab. Thank you.

12. I wish I could have devoted more time to this class but I had many personal problems this past semester and didn't have the time to devote completely to this course.

13. In the lab, you seemed very understanding and willing to help. But, in class it seemed the opposite. Maybe you assumed we knew what you were talking about. But I was left in the dark some times.

14. I think the laboratory work was extremely beneficial but in studying for the final exam, I think it would have helped more if we could have studied our previous tests. That way you can see where you were more liable to make mistakes. With only a few minutes to look over tests before they are handed back in, you forget too much of it.

I also felt the book was more confusing than helpful. It was difficult in many cases to figure out what they were trying to get across.

15. To me this class has been very rewarding and I've enjoyed it very much. I have learned a lot about the new modern math that I thought I never [would] be able to handle. The only criticism [I] have was that the hourly test were too long for the amount of time given. Another thing that I thought was very good and beneficial was the lab. I hope you continue using it.

16. I enjoyed the lab work very much. Out of any math class I have ever had, this one with the lab was the most "unique."

I learned more from the tapes and slides than I have ever learned from any teacher. Learning math by slides and tapes sounds funny (awkward) but it sure was helpful.

17. Excellent lab usage, good idea and feeling from you that you really cared about the students and that you did understand their problems. Too often teachers, math especially, place themselves above the problems of a few students and move on to the next idea or problem. I enjoyed the course quite a bit.

18. I truly enjoyed your class; sometimes I wonder if I would have made it without the lab, tho.

Have a nice vacation and good luck working on your Ph.D.

By the way, I felt the final was much too hard, compared to our class tests.

19. I feel your math lab was a big success and I know I couldn't have done as well as I have without the help it gave me. This has been one math course that I really didn't dread coming to.

20. Actually, though, I found this math hard, (as I've been away from all Math close to fifteen years), it is a very fascinating field which is very vast.

As some of this began to dawn on me, I do believe, if I had devoted more time, step by step to this particular subject, I could've gotten more out of it. (All my studying must be done away from home--during school hours only--) and with seven people at home three days and weekends, evenings, etc. must be devoted to keeping things running there.

Yes, this is a very worthwhile field, these modern concepts and better ways of thinking and doing.

21. This was a very enjoyable class, and I was able to understand math more, because of the different approaches you gave us. Your suggestions for teaching will be valuable for my teaching career. The math lab was very helpful.

22. You are a very pleasant person to be around. I enjoyed your class very much & I hope that some day I will be as acquainted with my material as you are in order so I can make a good math teacher some day.

23. The labs were very helpful and made all the material much easier to understand.

24. You're a very persistent teacher. Good luck in the future.

25. Going to the lab was very helpful, but I didn't work as hard as I should of in this course. I found that in high school the math was much easier for me, maybe because I put more time in.

26. Your teaching of math for elementary teachers was very helpful to me. When I had a question you were always concerned that I learned how to find the answer myself. When I did not catch on right away, you didn't get impatient but reviewed once again.

You have a way of making us want to learn and be able to teach.

You are a very understanding and patient. Too bad all my teachers aren't like you.

Maybe my grades don't show it but I learn more in this class than in any other. Sure, the grade counts but to me what I learned is more important.