This is to certify that the

dissertation entitled

A COMPARATIVE EVALUATION OF PROGRAMMED AND LECTURE INSTRUCTION IN COLLEGE BUSINESS MATHEMATICS

presented by

Manfred E. Swartz

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Teacher Education

Eddie A. Moore
Major professor

Date April 15, 1985

A COMPARATIVE EVALUATION OF PROGRAMMED AND LECTURE INSTRUCTION IN COLLEGE BUSINESS MATHEMATICS

By

Manfred E. Swartz

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Teacher Education

1985

ABSTRACT

A COMPARATIVE EVALUATION OF PROGRAMMED AND LECTURE INSTRUCTION IN COLLEGE BUSINESS MATHEMATICS

By

Manfred E. Swartz

The evaluative study was conducted during one 11-week term using 235 students enrolled in Business Mathematics 121 at Ferris State College, an open-admissions institution specializing in occupationally oriented business, health, and technical programs. The two instructional treatments employed in a nonequivalent control group design were (1) programmed, self-paced (n = 123, two sections) and (2) lecture, teacher-paced (n = 112, five sections). Special attention was given to aptitude-treatment interaction.

Pretests included the ACT Mathematics test, which was used for four-level blocking (High, Mid-High, Mid-Low, and Low) in the ATI investigation; the three additional ACT tests; the Mathematics Attitude Inventory; and a background questionnaire. Posttest measures were a comprehensive final examination and the final course grade. The comprehensive final examination was used as a pretest in one section.

Representativeness of the two treatment groups was ascertained by traditional methods. A t-test applied to the estimated gain scores produced large t-values for each method ($p < .001$), and a comparison of the mean gains favored the programmed method ($p < .05$). The analysis of variance F-value for the ATI was significant ($p < .05$). Scheffe's post hoc comparisons identified the superiority of the programmed method for the High and Mid-Low aptitude groups. Interestingly, the Mid-Low lecture group's achievement fell below that of the Low lecture group. Further analysis revealed that preexisting differences in attitudes toward mathematics (motivation) were associated with the achievement of Mid-Low and Low lecture groups. Students who scored 17 and below on the ACT Mathematics test had less than an 80 percent chance of earning a "C" or better. Stepwise multiple regression showed that grade prediction was aided by the use of the Self-Concept in Mathematics attitudinal scale. There were no differences attributed to students' preferences for the method of instruction (Hotelling's T^2).

Recommendations included (1) the replication of the study, (2) the use of attitudinal assessment and four-level blocking in ATI studies, (3) the continued use of both instructional methodologies for business mathematics, but greater use of the programmed treatment, (4) a prerequisite learning experience for some students, and (5) future placement and sectioning studies using the discriminant analysis method and including measures of cognitive style.

ACKNOWLEDGMENTS

I am grateful to many people for their assistance and support throughout the course of my doctoral studies. I wish to express sincere appreciation to the following:

The Ferris State College administration who initiated a cooperative program with Michigan State University and who provided continued support: Vice-President Donald Priebe, Associate Vice-President Gary Nash, Dean Karl Walker, and Dean Joel Galloway.

The doctoral committee: Dr. Ed Moore, Chairman, for his expert guidance; Dr. Rex Ray, for beneficial consultation and valuable instructional experiences; Dr. Ben Bohnhorst, for the many new concepts he imparted; and Dr. Charles Eberly, dissertation director, for his able editing assistance and assuring attitude.

The Office Administration department: Dr. Mal Lund, Department Head; Professor Vern Benson; Professor Bill Bennett; Professor George Hewitt; Professor Jim Lindsay; and Professor Rose Ann Swartz.

My family: Rose Ann, for her enduring confidence; and Mark and Matt, for their unquestioning recognition of the demands.

The office staff: Aggie Dora, Linda Burnes, and Kathy Gregorich, for unknown hours of typing and proofreading.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Educators recognize the need for evaluation of teaching and learning activities sponsored within educational institutions. Brinkerhoff et al. (1983) said that evaluation should be part and parcel of any educational effort. Bohnhorst (1982), in discussing the curriculum planning time-line, stated that an adequate concept of curriculum includes evaluation of the results of instruction. In defining a program as a set of procedures designed to accomplish a particular objective, Ebel (1980) stated that "program evaluation has been generally accepted as an important aspect of the educational enterprise" (p. 281). McKinney (1977) noted the growing demand for efficient and effective education and stated that "the issue is not whether to evaluate, but how" (p. 1). Thus, evaluation is viewed as a very important aspect of educational activity.

Purpose of the Study

To respond to the need for evaluation of an educational program, this study was designed to evaluate selected aspects of the business mathematics course (Business Mathematics 121) at Ferris State College. The principal aim was to judge the worth of two instructional methodologies, lecture and programmed, now in use. A further aim was to determine whether the former practice of sectioning students by ability levels should be reinstated. The study also examined instructional effects that are relevant to a growing body of literature on aptitude and treatment interactions.

The study focused on whether or not both lecture and programmed teaching methodologies should be continued, and potential changes that might be made to optimize student learning. Information was developed about the characteristics of students in each instructional treatment, the amount of gain in business mathematics knowledge under each treatment, the advisability of a prerequisite course for certain students, the advisability of ability-level sectioning for different methodologies, and the value of using attitudinal as well as ability measures in sectioning decisions.

Need for the Study

The need for the study grew out of current educational practices and decisions to be made about the course by the Ferris State College business mathematics faculty. The need was further justified by the study's relationship to aptitude-treatment interaction theory.

Setting of Ferris State College

Ferris State College provides occupationally oriented educational programs for students from a variety of academic backgrounds. Students who complete high school with less than a 2.00 grade point average are admitted to a general studies curriculum. Upon earning at least a 2.00 grade point average, they are eligible to select another program of study. In contrast, professional programs such as Optometry, Pharmacy, and Computer Information Systems attract students with strong academic backgrounds in the mathematics and science areas.

The business mathematics course at Ferris State College serves students enrolled in two- and four-year degree programs. Since many programs are considered to be "open-admissions," students arrive with varying mathematics backgrounds.

Current Context

In an effort to respond to the perceived needs of students, two teaching methods were adopted. One used the traditional lecture method, and one used a self-paced method with programmed materials.

Until 1981, students were pretested at the start of the term and sectioned by ability level into one of the instructional methods. The upper one-fourth and lower one-fourth of the distribution were assigned to the self-paced treatment. The middle one-half was assigned to the lecture treatment. This approach permitted the high-ability group to move through the programmed material rapidly and exit from the course early. It also permitted the low-ability group to proceed at their pace with more individual help from the teacher and tutor. In the lecture method, a homogeneous ability group was formed, thus minimizing the problems associated with teaching to a wide ability range. Although this rationale had appeal, no research was performed to ascertain its efficiency. As a result, the practices drifted, and it was suspected that the full range of ability levels was present in both teaching methods. A systematic evaluation of student achievement was needed to lend credibility to the current practice or to aid in decision making for the future.

Relationship to Theory

College students differ in many important ways. Students may differ in ability, motivation, attitude, learning style, sex, and socioeconomic status, for example. As a result, teachers are expected to deal with classroom situations where a wide range of characteristics are present. This diversity presents a challenge to the typical classroom teacher whose goals are to maximize student achievement (Peterson, 1982).

The traditional approach to instruction--that of lecture, class discussion, and laboratory exercises--assumes that students who work hard are capable of achieving the instructional goals. Yet it is known that all students do not achieve equally well. Therefore, the study of individual differences, as they relate to classroom achievement, has become a matter of theoretical development and research.

Since the student learner can be characterized in different ways, it seems that an instructional design that accounts for individual differences has an opportunity to be more effective than one that treats all students similarly. An approach that matches students' characteristics with the properties of instructional methodology is required. There is a need for more knowledge about student characteristics that favor one instructional approach over another.

Cronbach (1967) and Gagne (1967) have suggested that no single instructional approach provides optimal learning for all students. More investigation which might identify the interactions between learner characteristics and instructional methodology is needed. Such studies may show which treatments will serve the largest number of students most efficaciously. In discussing the relationship between learner aptitudes and learning environments, Snow (1970) stated that:

> What is needed is a grand Darwinian matrix of organisms by environments where both can be characterized by many dimensions and partitioned to show the particular types of treatments where particular types of learners thrive. (pp. 67-68)

Thus, the need for the study of learner characteristics that will interact positively with instructional methods has been recognized.

Studies supported by this rationale have been named aptitude-treatment interaction (ATI) research. Such studies focus on what works, for whom, and under what conditions. This type of study may be considered an evaluative study (Grasso, 1979).

Research Questions and Evaluative Criteria

This evaluation of several aspects of student achievement was performed to facilitate decision making about how best to offer the Business Mathematics 121 course. Five research questions were posed with criteria for acceptance.

Achievement Gain for Two Methodologies

Should the offering of both lecture and programmed instructional methodologies be continued?

An affirmative answer required that both methods produce an equal gain in achievement. The expected gain in student knowledge from pretest to posttest in each methodology was stipulated as statistically significant at the .05 level of confidence. If either method yielded less achievement, that method was to be considered for abandonment. If both methods failed the criterion, a complete reappraisal of the teaching-learning conditions was planned. If both methods satisfied the gain criterion, then the respective gains were to be compared to determine their equality. If one method only was associated with superior achievement, adoption of that method was to be recommended.

Sectioning by Ability

Should sectioning by ability level for different instructional methods be reinstated?

This question, dealing with aptitude-treatment interaction, was related to the first question. Assuming the two methods were supported, there was a need to know how best to implement the methodologies for different student ability groupings. The stipulated statistical criterion was the .05 level of significance for the F-test for interaction. If achievement for different ability groupings varied with the instructional methodologies, then sectioning by ability level was advised.

Prerequisite Learning Experience

Should a prerequisite learning experience be established for students with low mathematics ability?

Students should have at least an 80 percent chance of earning a "C" or better grade in business mathematics when they enter the course. It was determined that if an ability grouping fell below 80 percent in earning grades of at least "C" level, a prerequisite course in mathematical skills and concepts was necessary. The 80 percent criterion, based on admissions test data, is currently used to determine course placement in mathematics and English at Ferris State College.

Attitude Assessment

Should attitudes toward mathematics be considered with mathematics ability in sectioning decisions?

If attitude assessment accounted for a significant increase in the prediction of achievement variance, above that of ability assessment, then attitude assessment and a multivariate procedure for sectioning were to be prepared for adoption. The decision criterion was the .05 level of significance for the F-value associated with the attitude measures.

Student Evaluation of Methodology

Should the collection of student opinions of the course methodology be implemented?

If students differed in their reactions to the course methodology, the continued collection of these data for course monitoring was to be recommended. The .05 level of confidence was used as the criterion for determining need for the recommendation.

Definition of Terms

The following definitions for terms used in the study provided a common basis for understanding.

Ability. The term "ability" was used to describe students' learning ability as measured by the ACT tests and high school grade point average.

Achievement. The term "achievement" referred to students' knowledge of business mathematics as measured by the final business mathematics test.

Aptitude. The term "aptitude" generally referred to a characteristic on which students differ. In this study the ACT mathematics test was used as the aptitude variable.

Gain scores. Gain in business mathematics achievement was estimated from pretesting one representative class with the final examination. The class mean was used to approximate the pretest business mathematics score for all students.

Lecture method. The term "lecture method" was used to describe the traditional, teacher-directed classroom where lecture and discussion are the primary modes of instruction and students are tested as a group.

Programmed method. The term "programmed method" was used to describe a classroom environment that is guided by a programmed text that permits students to proceed at their own pace. When instructional units are completed, students can be tested individually. Although self-pacing is under individual control, the assigned work must be completed by the end of the academic term.

Mathematics attitudes. The term "mathematics attitudes" is used to describe a set of attitudes toward mathematics as measured by the Mathematics Attitude Inventory (Sandman, 1973). Six scales comprised the instrument. They were:

1. Perception of the Mathematics Teacher--A student's view regarding the teaching characteristics of his/her mathematics teacher.

2. Anxiety Toward Mathematics--The uneasiness a student feels in situations involving mathematics.

3. Value of Mathematics in Society--A student's view regarding the usefulness of mathematical knowledge.

4. Self-Concept in Mathematics--A student's perception of his/her own competence in mathematics.

5. Enjoyment of Mathematics--The pleasure a student derives from engaging in mathematical activities.

6. Motivation in Mathematics--A student's desire to do work in mathematics beyond the class requirements.

Limitations and Delimitations

The evaluative study was conducted in an educational environment that imposed several restrictions. The restrictions also included those imposed by the design of the research.

Limitations

Two limitations included generalizability and nonrandom groups.

Generalizability. The study was limited in generalizability to students who enrolled in business mathematics at Ferris State College during the Winter Term, 1983-1984. The findings should not be routinely generalized to other academic terms or to other academic settings.

Nonrandom groups. The nature of class scheduling prevented random assignment of students to instructional treatments. Although randomization was not possible, representativeness was possible and was expected. This matter is discussed in Chapter IV.

Delimitations

The delimitations were concerned with the scope of the study and the comparability of instructional methods.

Variable selection. Educational evaluation can include a vast array of topics, too broad for a single study of this type. A focus is required. This study centered on student achievement and factors directly related to achievement.

Time factor. Comparisons between programmed and conventional instructional methods have suffered on logical grounds because the time factor has seldom been held constant. Programmed instruction usually includes self-pacing, which permits early departure from the treatment. Since self-pacing and early completion of course work are considered to be a part of the motivational strategy of the programmed methodology, the potential for time variations is an integral part of the comparison in this study.

Conduct of the Study

The study report proceeds with a review of relevant literature; then the procedures of the study are described. This material is followed by a description of the findings. The last section discusses the conclusions and implications for instructional decision making.

CHAPTER II

RELEVANT LITERATURE

An evaluative study is designed to assess the effects of instructional strategies and to make recommendations for the improvement of instruction. A complex set of factors are relevant to such an undertaking. These factors include the subject matter, the instructional method, the students' ability and attitudinal characteristics, the interaction of instructional methods and student characteristics, the variables used to assess the instructional effects, the statistical procedures used in assessing effects, and the decision making about student placement in optimal learning conditions. All of these factors are intertwined with features of the institutional setting where the study is conducted and, to some degree, the professional responsibilities of the researcher. Consequently, the review of literature touches a broad range of relevant educational factors.

Comparative studies that used two or more instructional methods in high school or college-level business mathematics were reviewed first. These were followed by studies that compared programmed, individualized, or personalized educational systems to the lecture method in subject areas such as college-level general mathematics, introductory algebra, developmental mathematics, or what is described in some settings as remedial mathematics. The ability level of a portion of the students in this study makes such literature relevant. The arithmetic/algebraic base of the business mathematics subject matter (Kaliski, 1975) added to the relevance of the studies. Then, studies that compared the traditional lecture method to a variety of methods in the general mathematical subject area were reviewed.

Studies that sought to identify aptitude-treatment interactions were reviewed next. These studies attempted to identify student characteristics that led to improved achievement in one or another instructional treatment. The intended outcome was a procedure for decision making about course placement. After a section on aptitude-treatment interaction, studies that involved course placement and promising variables not included in this study but relevant to subsequent studies of a similar nature were reviewed.

Business Mathematics

Seven studies that compared instructional methodologies in business mathematics were reviewed. Four of the studies reported improved achievement with programmed or individualized approaches. One study reported mixed results, and the other two reported no differences.

Harsher (1983) investigated the achievement, achievement retention, and attitudes toward subject matter effects of three methods of teaching secondary business mathematics. The instructional methods were the (1) teacher-directed conventional method, (2) student-directed individualized method, and (3) student-directed competency-based method. The study used random assignment of classes to treatments in a pretest-posttest control group design. Thirty-two classes in 17 high schools participated. Students in the individualized and competency-based groups received self-instructional packages. However, the competency-based packages included goal-related components. The study produced mixed results. An analysis of covariance on achievement measures yielded no significant differences. Analysis of covariance was deemed inappropriate for retention and attitudinal measures; consequently, Johnson-Neyman solutions were used to locate regions of significance on specified ranges of covariables and between pairs of treatment groups. For some students, self-directed instruction that included goal-related information appeared to elicit superior retention results as compared to self-directed instruction without goal-related information. For other students, self-directed instruction appeared to be superior to teacher-directed instruction in eliciting favorable attitudes. For still other students, self-directed instruction without goal-related information appeared to elicit more favorable attitudes than self-directed instruction with goal-related information.

Miller (1984) experimented with the use of a remedial mathematics program for adult business mathematics students who scored at or below the 9.9 grade level in the mathematics fundamentals part of the Test of Adult Basic Education (TABE). Eighty students were involved in a posttest-only control group design with random assignment to groups. Forty students received the Individualized Manpower Training System (IMTS) remedial program; the control group did not. The purpose was to determine whether participation would increase achievement in business mathematics and decrease the failure and dropout rate. The MANOVA results indicated that the achievement level of the IMTS group exceeded that of the control group ($p < .05$). However, no significant differences were observed in the number of students who passed, failed, or dropped the course.

Brown (1984) compared programmed instruction to the lecture-demonstration method of instruction in high school business mathematics by using a nonequivalent control group design. Programmed business mathematics review materials were prepared to fit the unique format of the vocational office education class. Units involving numeration and whole numbers, decimals, fractions, and percentages as used in business were developed. Each unit was followed by a review unit and a unit test. The material was designed to be completed in six to eight hours. Eighty students enrolled in six pre-employment vocational office education classes participated in the study. Three classes received the programmed material and three received the traditional approach. Analysis of covariance revealed that the programmed instruction method yielded a higher level of student achievement ($p = .076$).

Wells (1982) compared university student achievement in business mathematics by comparing an individualized approach to the traditional lecture approach on two instructional units, percentage and business applications. The data were statistically treated using a multivariate analysis of covariance in a nonequivalent control group design. The findings indicated that the use of individualized instruction produced higher achievement than the use of traditional instruction.

In a nonequivalent control group design study of achievement in business mathematics, Liquori (1973) compared the Personalized System of Instruction (PSI) to the traditional lecture method. Two class sections were assigned to each method, with some variations in tutorial assistance within the PSI classes. The study also included an analysis of the effects of a graded and ungraded comprehensive final examination for each methodology. No differences between PSI and lecture methodologies were observed. However, students with graded final examinations in both methodologies revealed better posttest achievement than did those students assigned the nongraded final. The findings suggested that the anticipation of a summative evaluation might aid in the integration of course material and that this integration might not occur in PSI classes without summative evaluation.

Williams (1975) used a pretest-posttest control group design to compare a mastery learning instructional approach to a conventional strategy. The mastery strategy used small-group peer instruction, small-group teacher instruction, and programmed instruction. The conventional strategy used a lecture-discussion methodology. Both achievement measures and students' ratings were used in analysis of variance and t-tests for statistical testing. The mastery treatment accounted for significantly better achievement when the subject matter was of moderate difficulty, but not for the most difficult and least difficult units. Student ratings in the mastery strategy revealed a

preference for small groups with the instructor and small groups with peer instruction. Independent study with programmed materials was least preferred.

Oravetz (1966) used a nonequivalent control group design with testing for effects extended in time to compare the effects of daily drill patterns in business mathematics presented (1) by a tachistoscopic-type device, (2) by an instructor-prepared series of audio-oral rapid mental calculation exercises with each other, and (3) with no drill. The drill groups received 10 to 15 minutes of the respective presentations in each class session. At the conclusion of the course, both drill groups revealed higher achievement than the nondrill control group; this difference held when assessed six weeks later. When student background was considered, the drill effects were not apparent for those with more than two years of high school mathematics. The drill patterns appeared to be most effectively suited for students with less than two years' previous mathematics instruction.

In another review of comparative studies in business mathematics, Brown (1984) cited three studies (by Myers, Swindle, and Pappin) where higher achievement was experienced by students in programmed methods. However, studies by Folz and Neaville (in Brown) found no differences.

In summary, Brown's review and this review located 12 studies of instructional methodology in business mathematics. Eight studies found achievement or other features that favored the programmed approach, one found mixed results, and three reported no difference.

In no case did the lecture approach prove to be superior in business mathematics instruction. Only two of the seven studies reviewed directly were of experimental design, and they reported results favoring the alternative to the lecture treatment. In four quasi-experimental studies, three studies reported results that favored the alternative to the lecture. One reported no differences. Thus, the relationship of the type of design used and the studies' outcomes appeared to be consistent.

Programmed and Lecture Methods

The lecture method of instruction, in such prevalent use, is at the root of considerable methodological research on student achievement in mathematics. Support for the lecture method can be found readily. Mackenzie (1975) noted that as students hear the lectures, see the lecturer, see the argument unfolding at the chalkboard, and take corresponding notes for themselves, the communication becomes more enriched than with independent reading from a text covering the same material. He added that the lecturer's ability to enhance what is said or explained through sidelights or anecdotes from the rich history of the discipline, or with illustrative examples to reinforce the topic under consideration, makes the lecture method potentially effective in improving the learning and attitudes of students. In contrast, Weisenglass (1976) believed that the lecturer, no matter how hard he/she tries, cannot present new information in the correct context and at the correct pace for all the students. Some are bored because the pace is too slow; some are confused because the pace is too fast.

Others have recognized that the lecture has a place for some types of instruction. For example, Woods (1983) asserted that the linking of a lecture's purpose to its form and structure helps faculty to organize instruction. He considered the classical model of instruction best to transmit information, the problem-centered model to create interest, and the sequential approach to promote understanding.

Mathematics education is an excellent medium for research on the effectiveness of the lecture method. The lecture has frequently been compared to the programmed method, as in this study, and to other teaching methods.

J. Adams (1981) compared student achievement in programmed and lecture methods of teaching remedial college algebra. The pretest-posttest control group design included testing for effects extended in time. One hundred sixty-four randomly selected students (82 per group) were pretested to determine levels of algebra achievement and attitudes toward mathematics. One hundred thirty who completed the course were posttested. The course withdrawal rate was 21 percent. Analysis of covariance revealed a significant difference in achievement ($p < .001$) favoring the programmed method. Mathematics background was more influential than attitude in predicting achievement. Follow-up in a regular algebra course produced no differences in achievement related to the method of prior instruction.

R. Adams (1981) used a nonequivalent control group design with pretesting and posttesting to compare student achievement resulting from the personalized system and lecture method of teaching intermediate algebra. Although the sample sizes at Yarapai College were small, the personalized system produced significantly higher achievement scores. Attrition from the two methods was equal.

Watson (1983) compared an individualized system of instruction with a choice of assessment to the traditional lecture method with an end-of-course examination. The students were enrolled in a mathematics course, Discrete Modelling I, over a three-year period at an Australian university. The design used intact class groups in a nonequivalent control group design with separate samples covering a three-year period. With attitude and achievement as outcome measures, the individualized system produced better attitudes and a higher passing rate, but the lecture group had better long-term retention of concepts. It was suggested that preparation for the end-of-course examination in the lecture treatment aided in long-term retention.

Schielack (1983) assessed the relative merits of the Keller Personalized System of Instruction (PSI) and the traditional lecture-discussion method in mathematics achievement and attitudes for elementary education majors. A pretest-posttest control group design was used. Also investigated was the existence of aptitude-treatment interaction using general reasoning ability as an aptitude measure. The sample consisted of 30 PSI and 28 lecture students. PSI students performed significantly higher ($p < .001$) than lecture students on the

final examination and had significantly more positive ($p < .05$) attitudes toward mathematics. There was no aptitude-treatment interaction.

Reinauer (1981) investigated the use of aptitude and attitudinal measures in predicting technical mathematics achievement taught by a computer-assisted, self-paced method and the conventional lecture method. Interaction between student characteristics and instructional methods was considered also. The sample for analysis in a pretest-posttest control group design consisted of 88 students selected from seven lecture sections and 72 students from six self-paced sections. The pretest measures, verbal reasoning, numerical ability, student attitudes, mathematics enjoyment, and mathematics anxiety, accounted for 37 percent of the achievement variance. There was no significant treatment interaction; consequently, placement decisions were not recommended. Overall, the self-paced group scored significantly higher than the lecture group, although this was not an indication of the efficiency of the self-paced instruction format for all students.

Shine (1983) compared the effectiveness of programmed instruction to lecture instruction in the teaching of digital computer arithmetic to 41 postsecondary electronic technology students. The analysis used a pretest-posttest, two-group simple randomized design. Students were randomly assigned to sample sizes of 21 and 20 and assigned to the programmed and lecture methods, respectively. Students were pretested and posttested with specially prepared digital computer arithmetic

tests. The conclusions were that both methods produced a gain ($p < .05$) and that the programmed method was as effective as the conventional lecture method.

Schwarze (1980) compared a mastery learning approach to conventional lecture instruction in a remedial mathematics program situated in an urban community college. The mastery learning procedures included short introductory lectures, carefully sequenced examples and problems, frequent formative testing, immediate feedback, and immediate corrective follow-up. The two-randomized-groups design was used. Students were pretested and posttested for achievement levels and attitudes toward mathematics. The two groups were equal on the pretest measures. On the posttest achievement measure, the mastery learning group performed significantly better than the conventional instruction group. In attitude assessment, the mastery learning group revealed a slight increase, while the conventional instruction group showed a significant decrease.

Truckson (1983) explored the development of junior college students' problem-solving ability in arithmetic by comparing three methods of instruction: (1) the lecture method, (2) the heuristic method with problem solving, and (3) the lecture method with problem solving. The design was a pretest-posttest nonequivalent control group that used analysis of covariance. The instructional period was nine weeks in length, and posttests included both achievement and attitude measures. The methods using problem-solving instruction produced significant evidence that problem-solving skills were used.

The processes being taught were being used on the tests. However, in actual arithmetic achievement, the three methods were equal.

Walker (1981) compared the traditional lecture-discussion method with the lecture-discussion method supplemented with a programmed text to teach arithmetic concepts to prospective elementary school teachers. The pretest-posttest control group design was used. Effectiveness was examined by achievement and attitudinal measures that were administered as pretests and posttests. Results were based on sample sizes of 23 students in each treatment group. All of the null hypotheses were supported. The addition of programmed support materials did not produce increased attitude or achievement gains over results for the traditional lecture-discussion method.

Cope (1980) compared the lecture-discussion method of teaching business calculus to the lecture/small-group-discussion method. The experimental group received lectures two days a week with small-group discussion on the following two days. The nonequivalent control group design with pretest and posttest was used. Students in the lecture-discussion group performed as well as those who experienced the lecture four days per week. The students in the experimental class experienced significantly fewer withdrawals, failures, and absences. They also indicated a strong preference for the experimental method.

Bouknight (1984) investigated the effects of two teaching strategies with different emphases on two dimensions of learning outcomes in an introductory college mathematics course. The verbal strategy emphasized the interrelationships of the content, providing

students with opportunities to express verbally their understanding of the relationships. The computational strategy stressed computational skills and procedures, providing routine drill-like exercises for the development of computational competency. Ninety-nine students were randomly assigned to one of the two teaching strategies in a posttest-only control group design. For four consecutive class periods students received instruction via video-taped lessons and were assigned appropriate homework. On the fifth session they were posttested and a retention test was given six weeks later. Based on the posttest data, evidence of the two learning outcomes was confirmed. The instructional strategy influenced verbal knowledge outcomes ($p < .0001$) and computational knowledge outcomes ($p < .05$). However, the retention test supported only the verbal strategy ($p < .0001$). For short-term goals both strategies were effective; however, for longer-term retention, instruction should emphasize the verbal expression of interrelationships in the subject matter.

Godia (1982) investigated the student achievement and attitude change for college freshmen enrolled in remedial arithmetic under two different instructional approaches. A posttest-only control group design with random assignment to groups was used. One group of 227 students was assigned to a small-group-instruction approach that used calculators, an instructional support system, and a textbook. Class size ranged from 25 to 30 students. The second approach enrolled 94 students in a large-group-instruction mode using diagnostic remediation and instructor-made materials. Two-factor analysis of variance showed

that achievement in the small-group approach was higher ($p < .001$), although both groups showed substantial gain. Both groups experienced positive improvement in attitude toward mathematics, but the gain was greater on the part of the large-lecture group ($p < .05$). Both groups had low attrition rates, but the small group had a significantly lower rate ($p < .05$).

Artz (1984) compared the traditional lecture method to a student team method of teaching high school mathematics. The 342 subjects were from the ninth, tenth, and eleventh grades from three high schools. The student team method used within-class groups where ingroup cooperation was stimulated by intergroup competition. A non-equivalent control group design was employed. Measures of achievement, attitude, and social interaction were obtained. Results indicated that the student team method produced fewer missed homework assignments ($p < .0005$), greater student participation ($p < .0005$), and greater use of the teacher ($p < .005$) than the traditional lecture method. The measures for student achievement, mutual concern, and peer support for academic achievement were related to different teacher implementations of the method and could not be compared reliably.

Thirteen studies were reviewed in this section. Six studies compared the traditional lecture method to some form of programmed, individualized, or self-paced method. In these studies, the programmed method proved superior in five cases, and no difference was found once. The latter study had very few students involved. Seven studies compared the lecture method to other instructional treatments, four of

which involved some type of small-group-discussion method. In these studies, one favored the lecture method, two favored the discussion method, and one could not be determined. In the other three studies, the methods were found to be equal twice and the alternative to the lecture favored once.

Sample sizes employed in this set of studies were relatively small. Only 2 of the 13 studies used over 70 students per treatment. However, the majority of studies were of experimental design, 8 of 13. Those studies that found no difference between methods were split between experimental and quasi-experimental designs.

In summary, these studies revealed that the popular lecture method produced superior achievement in 1 of 13 studies and produced equal achievement in three studies. Seven studies favored the alternative method--four of which were of the programmed, self-paced type. Consequently, it appears that the lecture method warrants further comparison to other educational methodologies. Its widespread popularity may be based more on instructor convenience than on its relative contribution to student achievement.

Aptitude-Treatment Interaction

A substantive problem in education today is to learn which characteristics of the student interact dependably with which features of instructional methods. This is a problem of great magnitude. Students differ in many ways, and instruction can be delivered by a variety of methods. Controlling the conditions under which hypotheses are tested and data are collected has proven difficult. No interactions are so well confirmed that they can be used directly as guides to instruction (Cronbach & Snow, 1981).

This review identified 11 relevant mathematical studies reported since 1980 that sought to identify aptitude-treatment interactions. Reviews conducted by Cronbach and Snow (1977) and Tobias (1981) were cited as well.

Harkins (1980) compared the effects of three methods of instruction (individualized, small-group, and lecture) on achievement, attitudes, and anxiety in college-level remedial mathematics. Three intact classes, one for each treatment, were used. The total sample included 76 students. Hypotheses were tested using analysis of variance and covariance. Interestingly, attitude (not aptitude) treatment interactions were found. Results indicated that the individualized format was more effective in eliciting achievement on the part of low-anxiety students, while the lecture method was more effective in eliciting achievement on the part of high-anxiety students.

T. Smith (1983) found aptitude-treatment interaction in a comparison of college algebra students who experienced self-paced instruction and traditional instruction. A nonequivalent control group design and 70 students were used. The main effects for the two treatments were equal. There was no significant difference attributable to method. However, students with the strongest mathematics backgrounds performed significantly better in the self-paced course, while students

with the weakest mathematics backgrounds performed better in the lecture method.

Hickey (1980) investigated the relationship between reasoning ability, locus of control, and achievement in finite mathematics offered in high-support and low-support methods. The high-support method was teacher directed. The low-support method involved the student in developing the structure of the knowledge from theoretic constructs provided by the teacher. A pretest-posttest control group design was used. Over 200 students were involved in the study. The high-support and low-support treatments were equally effective in producing achievement overall. No significant interactions were found on the final examination. However, the data were consistent with the hypotheses; that is, students who were high in general reasoning and internal locus of control benefited more from a treatment where some of the course structuring was left to the learners, and students lower in general reasoning ability and external locus of control benefited more from a treatment where the structuring of course content was provided by the teacher.

In a search for a good match between teaching method and student, Urbatsch (1980) examined three methods of teaching remedial college mathematics: (1) personalized system of instruction (PSI), (2) traditional three-day lecture, and (3) five-day lecture. Comparisons were made on measures of achievement, attitude, and locus of control. The presence of aptitude-treatment interactions was also investigated. Matched pairs and matched triples of students were

selected from course completion. Multivariate analysis of variance was used for statistical processing. No significant main effects were found. However, external locus of control students were found to achieve higher scores in the three-day lecture than in PSI, while internal locus of control students achieved higher scores in PSI than in lecture. Since aptitude-treatment interactions were found for attitudes, the author concluded that locus of control seemed to be important when advising students about selecting a teaching methodology.

Witkowski (1982) compared the use of two types of supplementary materials in a college remedial algebra course. The experimental group used cognitive-oriented supplementary material with the lecture method, and the control group used drill-oriented supplementary material with the lecture method. A pretest-posttest control group design with 30 students was used. Positive trends for the use of the cognitive materials were observed. Aptitude-treatment interaction was present. Students with SAT scores above 400 and cognitive materials performed better ($p < .05$), and there was a significant difference ($p < .05$) in retention of linear-function material favoring the cognitive materials group.

Payne (1984) studied the effectiveness of three methods of teaching problem solving in general education mathematics to junior college students. Students were randomly assigned to three treatments: (1) the flowcharting method ($n = 27$), which used typical computer programmer flowchart techniques, (2) heuristic ($n = 25$) which used a method built around Polya's heuristic approach, and (3) structural questioning (n = 20) which used an approach designed by Phillips and Soviano (Payne, 1984). Students received pretests, posttests, and retention tests designed to measure problem-solving ability on typical and novel verbal problems. The gain in problem-solving ability was significant ($p < .001$) for all three methods. There was no significant loss of problem-solving ability evident on the posttest for all methods. Thus, the methods were considered equally effective. Twenty-four analyses were performed to test for aptitude-treatment interactions between student variables (as measured by the Nelson Denny Reading Test, SAT verbal test, and the SRA IQ scores) and teaching methods. Only three were significant ($p < .05$) and interpretable.

Higab (1983) studied the possible effects of selected aptitudes and two methods of organizing materials for teaching. Four intact groups of high school students (n = 58) were randomly assigned to two instructional methods. The structured method was highly sequenced and logical, and the scrambled method was deliberately disorganized by using a table of random numbers. Variables used were quantitative aptitude, reasoning aptitude, language aptitude, and sex. Instruction was delivered in four sessions. At each session a unit was taught for about 30 minutes, and 15 minutes was reserved for administering achievement tests and satisfaction questions. All combinations between aptitudes, sex, teacher, and treatment were considered with the criterion variables (achievement and satisfaction). Of the 18 hypotheses, only two showed significant aptitude-treatment interaction. One was the relationship between reasoning aptitude and teacher, with achievement as a criterion variable. The other was between quantitative aptitude and sex, with achievement as the criterion variable.

Muzik (1984) examined several relationships between ability, allocated time, time on task, and achievement for high school students in an algebra class. Small-sample statistical techniques were applied to observer-collected data. The study used the single-subject a-b-a-b design. Two students each from high-, medium-, and low-ability groups were observed for nine weeks. During that period, they received seatwork assignments of various time durations (3 to 15 minutes). Results for time on task showed that high-ability students were superior (86 percent) to medium-ability students (76 percent), who were superior to low-ability students (64 percent). Aptitude treatment interactions for time were found. For nine to ten minutes of allocated time, low-ability students were more on task than medium- or high-ability students. For 15 minutes of allocated time, time on task had returned to baseline levels. Allocating time for seatwork had greatest effect on the achievement of low-ability students. There was an apparent threshold of 13 to 15 minutes before effective learning occurred. Medium-ability students exhibited improved achievement with a five- to seven-minute time threshold. High-ability students' achievement was not associated with varying the allocated time. Also, aptitude-treatment interactions for achievement were noted when allocated time was extended (13 to 15 minutes). Low-ability students surpassed the other ability-level students in achievement.

McComb (1984) investigated aptitude-treatment interaction in mathematics course placement procedures by using a pretest-posttest nonequivalent control group design in a university setting. Students were placed in algebraic and calculus course sequences of long and short duration. Analysis of covariance was used to determine if aptitude-treatment interactions existed. No consistent interactions were discovered for either subject area. Students who enrolled at the recommended level tended to outperform students who enrolled in higher-than-recommended courses. Also, comparative treatments did not compensate for differences in initial ability. Grades were used as an outcome measure across two years, and there was evidence that grading practices changed during that time. Thus, it was recommended that course placement practices not be based on single-year data.

Robertson (1980) used a discriminant analysis technique to identify a set of pretreatment aptitudes which interacted with instructional treatment to produce differential effects in the achievement of college students enrolled in a course in arithmetic and elementary algebra. The two treatments were the programmed, self-paced method, and the lecture, teacher-paced method. The study had two phases. In the first phase, involving 371 students, a discriminant analysis was carried out to identify the pretreatment aptitudes that best discriminated between the highly successful students in each method. The seven best measures were verbal ability, debilitating anxiety, reason for taking the course, thinking motive, desire for self-improvement, dislike of school, and affiliating motives. A discriminant function was

developed to predict the best method for the student to receive. That function, when applied to the group, identified 122 properly placed students and 86 improperly placed students. The achievement means for these two groups were significantly different ($p < .001$). The study was replicated in a second phase and similar results were obtained. This study revealed that viable placement procedures of practical value can be developed and implemented for the purpose of matching students to instructional treatments and that discriminant analysis can be used effectively in ATI research. It was recommended that discriminant analysis be carried out on unsuccessful as well as successful students and that the effectiveness of the two functions be investigated.

Khan (1983) compared the effectiveness of programmed instruction to the conventional lecture method and lecture-laboratory method of teaching physical geography to university students. A pretest-posttest nonequivalent control group design involving 87 students was used. Students were categorized by high and low reading ability and instructional method. The lecture method proved to be superior to the programmed method, and there was no aptitude-treatment interaction. The lecture-laboratory group self-rated their method highest. The programmed-instruction group liked their method least.

One of the most comprehensive reviews of literature on ATI was published by Cronbach and Snow (1977). The focus of Chapter 7 of their book is on programmed instruction where ability was used as an aptitude measure. They found 13 studies where ATI was present and where

individualized instruction favored the low-ability group. In five of the cases, the conventional instruction favored the high-ability group.

In contrast, they found five studies where individualized instruction favored the high-ability group. In four of these cases, conventional lecture instruction favored the low-ability group. To complete the review, they found 12 studies that sought to find ATI, but did not. In all of these cases, both ability groups favored programmed instruction over conventional instruction.

In comparing the three outcomes described above, the authors observed that where no ATI was present the content of instruction was drill-like material. They found no principle that would explain the contrasting findings where ATI was present but concluded that the evidence encourages further research.

Another review of ATI research was conducted by Tobias (1981). He concluded that the lower the level of prior achievement the greater the return from highly structured instructional activity.

Five of the studies reviewed here (Harkins, Smith, Hickey, Urbatsch, and Witkowski) provided some evidence of aptitude-treatment interactions. The individualized, self-paced method was associated with higher achievement on the part of students with low anxiety, strong mathematics backgrounds, high general ability, and internal locus of control. The traditional lecture method was associated with higher achievement for students of high anxiety, weaker mathematics background, lower general ability, and external locus of control.

Only one of the studies (Hickey, 1980) used over 100 students per treatment as recommended by Cronbach and Snow (1980), and it found no ATI. Most studies used fewer than 50 students per treatment, and Muzik (1984) used only two students per treatment. Five of the studies used an experimental design, two of which reported the presence of ATI. Three of the five quasi-experimental studies found ATI. Also, the studies varied considerably in use of instructional methods, instructional content, and definition of aptitudes.

The Payne (1984) and Higab (1983) studies demonstrated the difficulty in identifying aptitude-treatment interactions where, respectively, only 3 of 18 and 2 of 18 hypotheses were supported. In these studies, the potential for a Type I error in the findings seemed high. The study by Muzik (1984) used a small-sample, clinical approach to the study of ATI. Another variation in ATI study was offered by McComb (1984) and Robertson (1980). In these studies, treatment variation was perceived of as an alternative series of courses, not simply a within-course variation. The Robertson study used a multivariate approach with discriminant analysis statistical treatment to make the groups as distinct as possible, whereas the McComb study used a univariate approach to assigning students to groups. Cronbach and Snow (1977) provided a comprehensive literature review which illustrated the complexity and the contradictory nature of ATI research.

Course Placement

Aptitude-treatment interaction can be thought of as integral to the management of a single course, as it is in this study where the

instruction is varied for a group of similar students. Instructional treatment can also be viewed as a continuum of courses, as it was in the previously reviewed McComb (1984) and Robertson (1980) studies where students were placed based on prior achievement/aptitude levels. An aspect of this study was to determine whether a prerequisite course to business mathematics was advisable. Consequently, literature dealing with college remedial mathematics instruction and predictors of student success in mathematics courses was relevant to the study.

The high individual and institutional costs of providing remedial mathematics instruction in four-year institutions of higher education brought about a study at Ohio State University of a collegiate remediation course delivered in the high school setting (Rhodes, 1984). A basic college-preparatory mathematics course was field tested in 57 classes in 41 high schools during 1982-1983. Students were tested during their junior year on a college mathematics placement test. Those scoring at the lowest placement level, possessing essentially no algebraic skills, were viewed as the target population for the course to be offered during their senior year. Students were pretested and posttested on numeric and algebraic skills and were compared to the students taking similar course work at the university. An attitude survey was also used. The course proved successful in raising the placement level of 76 percent of the students. Using the pretest as a covariate, high school students outperformed university students on algebraic items ($p < .001$) while the reverse was true on numeric items ($p < .05$). No differences were found on the attitudinal scales.

T. Smith (1982) found that students who needed remediation in mathematics before taking college algebra and who followed the recommended remedial sequence earned higher college algebra grades than those students who used other sequences. Those same students stayed enrolled in the institution as long as those who did not need remediation.

Bone (1981) compared three methods of mathematics course placement for college students. Students were randomly assigned to a group where course placement was based on (1) a locally developed test, (2) ACT Mathematics and Coop Algebra II test, or (3) faculty advising based on conference, high school transcript, and ACT profile. Follow-up data were course grades (A, B, C being successful; D, F, N unsuccessful) and faculty ratings of student placement (too high, right level, too low). Faculty tended to place students too high, and these students experienced a higher failure rate. The two testing methods were equally effective. Students who followed the test recommendations were more successful than those who did not.

Sims (1980) used stepwise multiple regression to predict college algebra grades using a mathematics placement test, attitudinal measures, and demographic variables for 135 students. The final multiple R was .48. The set of the three best predictors were the placement test scores, age, and enjoyment of mathematics scale scores; they accounted for 21 percent of the variance in the course grade.

Bennett (1983) used the ACT tests, age, sex, race, and measures from the Computer Programmer Aptitude Battery to predict student achievement in a first college course in computer science. When the variables were combined, a total of 47 percent of the variance in grades was explained.

Helmick (1983) used an institutionally developed mathematics placement test, the overall high school grade point average, and the ACT mathematics score to predict college algebra grades. These variables accounted for 44 percent of the variance in the college algebra grade. In a second procedure for students who were designated as low achievers, the model accounted for 48 percent of the variance in college algebra grades.

Byrd (1980) used discriminant analysis to weigh and combine predictor variables so that precollege algebra and college algebra groups were as statistically distinct as possible. The three most discriminant variables were the mathematics placement test, reading comprehension score, and high school grade point average. The two classification equations correctly grouped 84 percent of the 233 cases. He also used three regression equations (linear, quadratic, and interactive) for the general mathematics group. The linear model accounted for 52 percent of the variance, while the quadratic and interactive models accounted for 53 percent of the variance on the final test.

The Rhodes (1984) study demonstrated that collegiate remedial course work can be delivered effectively in high school settings. The placement level was raised for 76 percent of the students. Two

studies, those of Bone (1981) and Smith (1982), found that placement recommended based on empirically developed procedures were preferable to other means of placement decision making. Studies such as the one by Sims (1980) reported that attitudes toward mathematics could be useful predictor variables, while the study by Glenn (1983) found that general measures of self-concept and self-esteem did not add predictive usefulness.

Varying degrees of mathematics predictability were found. The Sims (1980) study accounted for only 21 percent of the variance; however, Bennett (1983) and Helmick (1983) accounted for variance percentages in the range of 44 to 48. Most interesting was Byrd's (1980) use of discriminant analysis to facilitate placement decision making. Over 50 percent of the achievement variance was accounted for, and 84 percent of the students were correctly placed.

Cognitive-Style Variables

An evaluative study examines an educational program that exists, unlike an experimental study that creates a program to study. Integral to the evaluative study is the need to use measures that are presumed to have acceptance on the part of staff who must make decisions about the future. An evaluative study should also guide future inquiries. In addition to ability measures, this study used attitudinal variables which had promise for acceptance and produced needed information. Future studies might also consider another set of promising variables relating to cognitive style. As a step toward

influencing future inquiries, four studies dealing with cognitive-style assessment were reviewed.

Wilson (1982) examined the relationship of self-pacing and teacher pacing to cognitive styles in a basic mathematics college course. With the use of the Group Embedded Figures test, the 34 most field-independent and 34 most field-dependent students were selected and randomly assigned to the two treatment groups. All instructional materials and procedures were the same except the pacing. The self-instructional modules were identical. Self-paced students proceeded at their own rate, whereas instructor-paced students took the module quizzes according to a course calendar. The findings supported Witkin's theory of cognitive style. That is, instruction should be individualized in such a way that field-dependent students are matched with instructor-pacing and field-independent students are matched with self-pacing instructional modules.

Eldersveld (1982) used discriminant analysis to detect variables that helped explain student performance in developmental mathematics at the community college level. Traditional lecture instruction was experienced by 250 students, and nontraditional, self-paced instruction was experienced by 263 students. For the entire group, the variables of numerical skill, age, self-assessment of math knowledge, and self-assessment of mathematics attitudes and instructional method were discriminators. Canonical correlation showed that 9 percent of the variance was explained and 63 percent of the students were correctly classified as successful or unsuccessful. Similar results were found within each methodological group. Cognitive style did not prove to be an effective discriminator; however, it was observed that these students showed a strong tendency to be field-dependent.

Cullen (1980) found that many community college students were field-dependent and left-cerebral-hemisphere dominant. Those who were right-hemisphere dominant responded favorably to mathematics instruction that favored graphic and visualization techniques. Greater dependence on the left hemisphere was associated with comfort in the lecture method.

Hinton (1980) explored the relationships between several dimensions of cognitive style and their relationship to mathematics achievement, aptitude for mathematics, and attitudes toward mathematics. Students were randomly selected from six sequences of mathematical instruction in a community college setting. From the profile of cognitive-style dimensions, a discriminant analysis yielded two discriminant functions that differentiated students in the six sequences of mathematical study. Field articulation and the perceptive measure contributed to the discriminatory power of the first function; the systematic receptive measures contributed to the second function.

The cognitive-style research reported here was conducted in community college settings. Although definitive results were not observed, the findings had rational appeal. The setting may have interacted with the variables in such a way as to restrict the range of characteristics under consideration, thus suppressing the real effects.

Future studies that include both two-year and four-year college students may be more productive.

Summary

The literature reviewed in this study focused on instructional methods as applied in business mathematics and various levels of introductory college mathematics. In business mathematics, the programmed method was effective in most of the studies. In no case did the lecture method prove superior. Business mathematics studies that sought to identify aptitude-treatment interactions were not found. Other studies of mathematics achievement revealed that alternatives to the lecture method such as programmed, self-paced, or small-group instruction frequently proved to be superior. Only occasionally did the lecture method produce higher achievement.

The aptitude-treatment interaction studies reviewed here revealed the inconsistency and complexity of findings with such undertakings. These studies operationally defined aptitudes as abilities, attitudes, and cognitive style. Treatments varied and findings were mixed. The individualized approaches were sometimes associated with strong mathematics backgrounds, high ability, and internal locus of control. Students who needed more direction and had weaker backgrounds sometimes did better with the lecture method.

The course-placement literature revealed that structured placement practices, if followed, can improve student achievement. Multivariate procedures can account for almost 50 percent of the variance in achievement. Stepwise regression and discriminant analysis can be useful statistical procedures in analysis of optimal course-placement procedures. Cognitive-style measures, not included in this study, may be used constructively in future studies.

This review demonstrates that some, but not extensive, research on student achievement in business mathematics has been conducted. The inquiry into aptitude-treatment interactions in college business mathematics will represent a contribution to the literature.

CHAPTER III

PROCEDURES

The following research procedures were established to evaluate student achievement in Business Mathematics 121 at Ferris State College.

Population

The population of the study was all students who enrolled in the business mathematics course at Ferris State College during the winter term, 1984. Most of the students were freshmen and sophomores majoring in business fields. Others were majors in the General Education and Allied Health schools at the college. Student ages ranged from 18 to 50 years old; however, at least 90 percent were 18 to 20 years of age. Sixty percent of the enrollment were female; 40 percent were male. Approximately 40 percent of the students were enrolled in Associate degree programs, while 60 percent were enrolled in Bachelors' degree programs. The final sample for the study consisted of 235 students who completed Business Mathematics 121 at Ferris State College in the winter term, 1983-84.

Research Design

The design of the study provided a framework for the evaluation in such a way as to minimize rival explanations of the findings.

Basic Design

The basic design was a nonequivalent control group design with pretesting and posttesting. The lecture treatment group was the control group. There was no random assignment to treatments; however, representativeness of characteristics in the actual groups was possible and is discussed in Chapter IV. Campbell and Stanley (1973) acknowledged that this design is well worth using where true experiments are impossible.

Pretest measures. Pretest measures included the ACT subtest scores and the ACT Self-Report of High School Grades taken from students' files. The Mathematics Attitude Inventory and the Business Mathematics Questionnaire were administered at the first class meeting. The Business Mathematics Final Examination (Swartz, 1982b) was administered as a pretest to one class section (n = 60) on the first day of class. That class was selected for its representativeness of the total sample (n = 235) across seven sections based on ACT Mathematics ability.

Posttest measures. The posttest was the Business Mathematics Final Examination. The final course grade was also used as a posttest measure.

Design. The lecture comprised five classes of approximately 23 students each. The programmed group comprised two classes of approximately 60 each. The ACT Mathematics test was used to establish quartiles for blocking groups in the research design (Table 3.1). Cronbach and Snow (1977) preferred two-level blocking and discouraged three-level blocking. Since there was special interest in the middle 50 percent of the distribution, four-level blocking was chosen for the design.

Table 3.1.--Nonequivalent control group design.

Mathematics Ability Blocking	Methodology	
	Lecture	Programmed
High	N = 25	N = 34
Upper middle	N = 27	N = 32
Lower middle	N = 23	N = 32
Low	N = 37	N = 25
Total	N = 112	N = 123

Rival Explanations

The nonequivalent control group design controls for all of the sources of internal invalidity (such as history, maturation, and testing) except regression (Campbell & Stanley, 1963). Since extreme groups were not used in this study, the regression effect was not considered a serious threat to internal validity. However, the design as used requires a discussion of teacher effects and attrition effects.

Teacher effects. Five instructors were used, three for the lecture method and two for the programmed method. The highest degree

for all instructors was the Master's degree, and all had had at least five years' experience teaching business mathematics with the method they used in the study. Teacher effects were not eliminated from consideration, but some control was present.

Attrition effects. Student withdrawal from instruction after the investigation began was monitored and reported. Optimal results from statistical processing require that the numbers in each cell of the design not differ decidedly. The test for equality of cell frequencies is reported in Chapter IV. Conditions for the number per treatment stipulated by Cronbach and Snow (1977) of at least 100 students were satisfied.

Evaluative Criteria

Four of the five evaluative questions used statistical testing to help judge the meaningfulness of results. The other question used an institutional standard as an aid to appraise the results.

Achievement Gain for Two Methodologies

The .05 level of confidence was used to determine whether estimated student achievement gains from the lecture and programmed methodologies differed from the null hypothesis of no gain. The same standard was used to assess whether the gains were equal in magnitude. The results were used to help decide whether the offering of both methods should be continued.

Sectioning by Ability

The .05 level of confidence was used to determine whether achievement was related to an interaction of student ability levels and instructional treatments. If such an interaction were present, then a sectioning practice should be reconsidered.

Prerequisite Learning Experience

An 80 percent success rate of earning "C" or better grades was used to determine what ability groups needed prerequisite instruction. Students in an unsuccessful ability group were candidates for a pre-course learning experience in arithmetic skills and concepts.

Attitude Assessment

A statistically significant (.05 level) increase in prediction of business mathematics achievement attributable to attitudes toward mathematics, beyond that attributed to ability, was considered adequate to warrant the adoption of a precourse attitude assessment.

Student Evaluation of Methodology

The .05 level of confidence was used to determine whether students differed significantly in their reactions to the course methodology they experienced.

Measurement Instruments and Variables

Measures used in the study were the ACT Assessment Battery, the Self-Reported High School Grades, Mathematics Attitude Inventory, Business Mathematics Questionnaire, the Final Examination, Final Course Grade, and the Methodology Evaluation Survey.

ACT Assessment Battery

The ACT Mathematics Usage Test, one of four tests in the ACT Assessment, was the aptitude measure used as a blocking variable. Other tests included in the Assessment were English Usage, Social Studies, and Natural Sciences. This group of tests is frequently used for college admission decisions and course placement decisions. At Ferris State College the test is required of all new students for academic advising and course placement decisions.

Mathematics Usage Test. The ACT Mathematics Usage Test is a 40-item, 50-minute examination which measures a student's mathematical reasoning ability. The solution of quantitative reasoning problems encountered in college courses is emphasized. Although a sampling of the mathematical techniques covered in high school courses is included, the test emphasizes reasoning rather than a memorization of formulas, knowledge of techniques, or computation skills.

The Mathematics Usage Test is varied in content (Table 3.2). Arithmetic and algebraic reasoning and operation include 40 percent of the items. In general, the mathematical skills do not exceed those included in high school plane geometry or first- and second-year algebra. The item format is multiple-choice with five alternative answers (American College Testing, 1973).

In a previous study, the correlation between the ACT Mathematics test and final grades in Business Mathematics 121 was 0.54, which established the predictive validity of the test for use as an instrument for sectioning by ability level (Swartz & Swartz, 1981).

Table 3.2.--Description of the ACT Mathematics Usage Test.

Content Area	Proportion of Test	No. of Items
Arithmetic & algebraic reasoning	.35	14
Arithmetic & algebraic operations	.10	4
Intermediate algebra	.20	8
Geometry	.20	8
Number & numeration concepts	.10	4
Advanced topics	.05	2
Total	1.00	40

ACT reports KR-20 reliability coefficients in the range of 0.85 to 0.91. The odd-even reliability coefficients are in the range of 0.86 to 0.90. The range of the standard error of measurement is 1.96 to 2.53 (American College Testing, 1973).

English Usage Test. The ACT English Usage Test is a 75-item, 40-minute test which measure students' understanding and use of the basic elements of correct and effective writing, including usage, phraseology, style, and organization. The content avoids recall of the rules of grammar and reference to grammatical rules that are in a state of transition. The content is proportioned as follows: grammar and punctuation--34 percent, sentence structure--26 percent, diction--23 percent, and logic and organization--17 percent.

The odd-even reliabilities from previous studies have a median of 0.90, with a range from 0.87 to 0.92. The median KR-20 coefficient is 0.89 with a range of 0.87 to 0.90.

Social Studies Reading Test. The ACT Social Studies Reading Test is a 52-item, 35-minute test that measures evaluative reasoning, reading, and problem-solving skills required in the social studies. There are two general types of items: one based on reading passages and the other on general background information obtained primarily in high school social studies courses. The items based on the reading passages require more than reading-comprehension skills. They require the student to draw inferences and reach conclusions; to extend the thoughts in the passage to a new situation; to make deductions from experimental or graphic data; and to recognize a writer's bias, style, and mode of reasoning. The content is proportioned as follows: History--29 percent; Government--27 percent; Sociology, Anthropology, Psychology--23 percent; Economics--21 percent.

The odd-even reliabilities from previous studies have a median of 0.87 and a range of 0.82 to 0.88. The median KR-20 coefficient is 0.85 with a range of 0.80 to 0.89.

Natural Sciences Reading Test. The ACT Natural Sciences Reading Test is a 52-item, 35-minute test that measures the critical reasoning and problem-solving skills required in the natural sciences. There are two types of items: one based on reading passages and the other based on information about science. The passages concern a variety of scientific topics and problems. The items require the

student to interpret and evaluate scientific materials and to apply the scientific reasoning process. The content is proportioned as follows: Biology--29 percent, Chemistry--25 percent, Physics--25 percent, and Physical Sciences--percent.

The odd-even reliabilities from previous studies have a median of 0.85 and a range of 0.82 to 0.88. The median KR-20 coefficient is 0.84 with a range of 0.80 to 0.87 (American College Testing, 1984).

Self-Reported High School Grades

As a part of the ACT Assessment, students are asked to report the latest grade before the senior year in each of the subject areas in which they are tested: English, Mathematics, Social Studies, and Natural Science. Since grades are accepted as a measure of high school achievement that helps predict college performance, the self-reported grades from the ACT had potential in the prediction of business mathematics performance. Also, the self-reported grades were readily available for computer-based data analysis, while the actual grades from the high school transcript were electronically inaccessible. In selected cases where self-reported grades were incomplete, the high school transcript was manually searched for an appropriate grade to enter.

The self-reported grades were exactly accurate for 78 percent of the students and accurate within one grade for 98 percent of the students. The self-reported grades correlation with actual grades ranged from 0.81 to 0.86. These correlations were within the range of reliability figures obtained for other measures of educational ability

(American College Testing, 1973). The average of the four self-reported grades was used in this study.

Mathematics Attitude Inventory

Previous attempts to establish a strong relationship between mathematics attitude and achievement might have failed because of the inadequacy of the attitude measures (Sandman, 1973). Most studies have employed instruments that yield a single score to represent an individual's attitude. Such instruments do not distinguish between aspects of mathematics attitudes, some of which may be more related to achievement than others. The effects of one facet of attitude may cancel or dilute another facet of attitude if combined in the assessment device. Consequently, a multidimensional instrument that possessed six scales was selected for use (Sandman, 1973). Forty-eight items comprised the six-scale instrument, eight items per scale. Students responded to a Likert-type, forced-choice response system (strongly agree, agree, disagree, strongly disagree). Items were scored 4, 3, 2, 1, respectively, and were summed across the eight items for each scale.

Over 2,500 Indiana and California students from the eighth and eleventh grades comprised the original study group. A confirmatory factor analysis revealed that the six scales had integrity. The scales were:

1. Perception of the Mathematics Instructor
2. Anxiety Toward Mathematics
3. Value of Mathematics in Society

4. Self-Concept in Mathematics

5. Enjoyment of Mathematics

6. Motivation in Mathematics

Pilot testing for validity and reliability. Since Sandman's inventory had not been used with college students, the instrument was administered to 270 college students in business mathematics in the fall and winter terms of 1981-82 at Ferris State College. Validity and reliability coefficients were computed for this group (Swartz, 1982a).

Construct validity data were revealed in the form of nonspurious item to scale correlations (Table 3.3). A comparison of the validity coefficients for the original norm population and the Ferris State College sample for each item showed high similarity. The mean of correlations for each scale for each reference group was computed also. Four of the scales showed higher mean values for the college group, and one pair of means was the same. The other scale showed a slightly lower mean value for the college group.

Coefficient alpha reliability coefficients for the norm group and the college group were compared (Table 3.4). As with validity coefficients, five of the scales compared favorably for the college group. One scale showed a slightly lower, yet acceptable, coefficient.

Business Mathematics Questionnaire

The Business Mathematics Questionnaire (Appendix A) was developed solely for this study. The questionnaire asked students to

Table 3.3.--Nonspurious item-to-scale correlations for the Mathematics Attitude Inventory.[a]

Perception of the Mathematics Teacher			Anxiety Toward Mathematics			Value of Mathematics in Society			Self-Concept in Mathematics			Enjoyment of Mathematics			Motivation in Mathematics		
Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot	Item	Norm	Pilot
31	.54	.67	7	.54	.62	1	.50	.45	4	.64	.71	26	.59	.76	3	.38	.26
40	.54	.67	11	.64	.65	9	.44	.51	10	.66	.76	28	.59	.72	8	.41	.44
44	.47	.76	20	.59	.62	12	.40	.33	16	.59	.59	29	.43	.60	14	.42	.40
46	.53	.51	25	.62	.78	15	.52	.54	19	.60	.67	45	.44	.66	32	.44	.45
5	.61	.56	34	.60	.66	23	.56	.48	22	.41	.56	2	.75	.63	37	.45	.45
17	.60	.81	36	.65	.65	24	.51	.50	30	.71	.78	6	.69	.65	41	.56	.48
21	.64	.69	39	.61	.72	33	.44	.51	35	.48	.55	13	.60	.57	42	.43	.38
27	.54	.62	43	.65	.83	38	.42	.42	48	.36	.36	18	.60	.54	47	.60	.57
Mean	.56	.66		.61	.69		.47	.47		.56	.62		.58	.64		.46	.43

[a]Norm data--Sandman, 1973.
Pilot data--Swartz, 1982a.

indicate their college class, the year of high school graduation, semesters of high school mathematics, number of previous college mathematics classes, and the college mathematics classes taken. The results aided in the description of the student sample for the study.

Table 3.4.--Cronbach's alpha reliability coefficients for the six scales of the Mathematics Attitude Inventory

Scale	Group[a]	
	Norm	Pilot
1. Perception of the Mathematics Teacher	.83	.88
2. Anxiety Toward Mathematics	.86	.89
3. Value of Mathematics in Society	.77	.77
4. Self-Concept in Mathematics	.83	.87
5. Enjoyment of Mathematics	.85	.88
6. Motivation in Mathematics	.76	.74

[a]Norm data--Sandman, 1973.
Pilot data--Swartz, 1982a.

Business Mathematics
Final Examination

The primary dependent variable, the Business Mathematics Final Examination, was a 33-item, four-option multiple-choice test (Appendix B). It was developed from an instructor-made, open-ended-items test that had been administered to both lecture and self-paced classes as a comprehensive final examination (Swartz, 1982b). An analysis of answers by type of instruction revealed some items were sensitive to the teaching methodology. These items were rewritten to eliminate that bias. It was pretested as a 34-item test, and, subsequently, one item was dropped because it lacked instructional relevancy.

The test content areas related to certain chapters, or units of instruction used in the two teaching methodologies (Table 3.5). Items were taken from the core of content common to both methods (Appendices C and D).

Table 3.5.--Content analysis of the Business Mathematics Final Examination: 33-item version.

Content Area	Number of Items	Lecture Chapter	Programmed Units
Percentages	3	10	1, 7
Bank statement reconciliation	2	3	1, 2
Taxes, tax rates	4	20	1, 14
Interest, principal, rate, time	4	14	2, 1-2
Discount, proceeds, and maturity value	4	15	2, 4-6
Interest--effective rate	1	17	2, 7
Markon and selling price	4	13	2, 9
Trade discounts	4	11	2, 12
Payroll, gross pay, and FICA	4	18-19	2, 13-15
Depreciation	3	25	Handout
Total	33		

To obtain options for the multiple-choice format, student errors were recorded and tallied for both methodologies. The most frequently obtained errors were identified and selected as distractors for the draft of the test. The 34-item version of the test was administered to 145 students at the end of the fall term, 1982.

The test yielded a mean score of 26.2 and a standard deviation of 6.03. The high score was 34 and the low score was 9. The Kuder-Richardson Formula 20 for reliability was 0.88, and all items were of approximate difficulty and provided positive discrimination (Table 3.6). These results seemed sufficiently satisfactory to allow the test to serve as the comprehensive final examination.

Table 3.6.--Difficulty and discrimination indices for the Business Mathematics Final Examination: 34-item version.

Item	Difficulty	Discrimination	Item	Difficulty	Discrimination
1	.84	.40	18	.61	.28
2	.90	.32	19	.93	.33
3	.96	.24	20	.88	.33
4	.74	.40	21	.54	.58
5	.76	.35	22	.49	.69
6	.95	.21	23	.64	.32
7	.84	.47	24	.54	.55
8	.72	.39	25	.63	.35
9	.83	.45	26	.45	.49
10	.89	.45	27	.86	.60
11	.89	.28	28	.86	.57
12	.91	.35	29	.87	.60
13	.94	.39	30	.88	.60
14	.76	.62	31	.76	.41
15	.63	.60	32	.88	.46
16	.82	.60	33	.76	.51
17	.57	.54	34	.66	.50

Course Grade

The second dependent variable was the final grade assigned by the instructor. Grades were assigned on a 12-point scale ranging from

A to F (i.e., A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0, B- = 2.7, C+ = 2.3, C = 2.0, C- = 1.7, D+ = 1.3, D = 1.0, D- = 0.7, F = 0.0).

Methodology Evaluation Survey

A standardized instrument that permitted students to evaluate the method of instruction without evaluating other instructional features was not located. Consequently, a seven-item questionnaire to which students could respond on a four-point, forced-choice, Likert-type scale was developed. The Methodology Evaluation Survey was administered to students during the sixth week of the term. The administration was timed to reach all students before those in the programmed, self-paced course completed the Final Examination and stopped attending class, and to avoid proximity to the administration of a classroom examination in the lecture method. The instrument was given to 225 of the 235 students who completed the course. Ten students were absent or did not respond.

The instrument (Appendix E) included three items (Items 1, 2, and 7) selected from an instructional-evaluation item bank developed by the Teaching and Learning Center at the University of Michigan. Items 3, 4, 5, and 6 were created specifically for the survey.

Validity. The items were reviewed by the teaching staff in the study and were considered to have face validity. Inter-item correlations were 0.59 for Items 2 and 3 and Items 4 and 5 (Table 3.7). The highest correlation was 0.85 for Items 3 and 7. The mean inter-item correlation was 0.68, which supported the instrument's construct validity.

Table 3.7.--Inter-item correlations for the Methodology Evaluation Questionnaire.

Item	Item 1	2	3	4	5	6	7
1	1.00	.74	.68	.72	.61	.63	.71
2		1.00	.59	.64	.63	.64	.62
3			1.00	.77	.65	.70	.85
4				1.00	.59	.69	.76
5					1.00	.69	.70
6						1.00	.70
7							1.00

Reliability. Cronbach's alpha, an accepted measure of reliability, was 0.94. Hence, the instrument proved to have a high degree of internal consistency.

Instructional Methodology

Two instructional methods are used in the business mathematics course, the traditional lecture method and the programmed, self-paced method. The respective methods and staffing patterns are described below.

Traditional Lecture Method

Each class was staffed by one professor who was responsible for all instructional activity, including order of topic presentation, student assignments, testing, and grading. A blackboard and an overhead projector were available for use in each classroom. A common text, Business Mathematics for Colleges (Rice et al., 1983) was used in the lecture course.

Programmed, Self-Paced Method

Each class was staffed by one professor and two upper-class tutors. This instructional methodology used Programmed Business Mathematics, 4th edition (Huffman, 1980). Each unit of materials included a survey test, unit objectives, instructional material, and unit posttest. The survey tests, varying from 8 to 14 items, provided the student with an indicator of the need to do the unit or skip it and do the unit's posttest. If the student achieved less than 100 percent accuracy on the pretest, he/she was directed to complete the unit. The units' objectives indicated what was to learned within the units. These objectives, similar to performance objectives, informed the student what kind of behavior (i.e., list, define, compute, explain, etc.) was to be applied to the content, although performance standards were not listed with each objective.

The instructional material was presented in a sequence of small steps or "frames" that included content and a question or problem. Correct answers, to be "hidden" before attempting the work, were provided on the left side of the page. If used as directed, the answers provided immediate feedback to the learner. The rate of presentation was student controlled. This format was highly similar to the description of programmed instruction provided by Schalock (1976).

At the end of the instructional units, the students answered questions on a posttest, called a "checkpoint." These tests varied in length from 30 to 35 items, and they were to be completed before the work proceeded to the next unit. In this part of the process, instructors corrected (or marked) the checkpoints but did not grade them. A performance standard was introduced at the checkpoint. Students who achieved a lower performance standard redid the missed items until the 75 percent level of accuracy was achieved.

The program technique was linear. All students moved through the same material, although at their own pace. After the question was answered, the student moved to the next frame, regardless of whether the answer was right or wrong. In the posttest phase, if the standard was not achieved, only the missed items were redone. Students were not directed to new material to cover the deficiency as is offered in the "branching" or "responsive" system of programmed instruction (Schalock, 1976).

Several units were then combined, based on similarity of content, for achievement testing and grading. Regardless of student performance on these tests, they proceeded to the next unit of instruction called for by the course outline. When individuals finished the content requirements, they took the comprehensive final examination and left the class. Some students completed the work in as little as six weeks, but about 70 percent required the entire ten-week period. Those who failed to complete the content in the ten-week term still completed the comprehensive final examination.

Data Collection

The study was conducted winter term of 1983-84 at Ferris State College. ACT test scores were requested from the college computer center when the class rosters were printed. The data were analyzed immediately to determine the most representative class to receive the Business Mathematics Final Examination as a pretest.

The Mathematics Attitude Inventory was the initial instrument administered on the first class meeting, followed by the Business Mathematics Questionnaire. The Final Examination was administered to the specially selected section on the second class meeting. Instructors were given a small supply of assessment materials for students who arrived at class for the first time on the second or third class day of the term.

The class selected to receive the Final Examination as a pretest was the 2:00 p.m. section, a large section which was to use the programmed method. A visual inspection of the ACT Mathematics test section averages revealed that the selected class was in the middle of the distribution. The representativeness of this class was verified by performing a multivariate test of significance, comparing its students to the other students on the ability and attitude measures (Table 3.8). The F-value associated with Hotelling's T^2 was 1.2438, with a probability level of 0.254, which did not approach significance. Of special interest was the difference in mathematics ability, 0.7 points. On this key measure, the t-value was 0.75 with a probability of 0.455. Consequently, it was concluded that there was no evidence to suggest

Table 3.8.--Multivariate ability and attitude comparison of class selected for Final Examination pretesting to other classes.

Measure	Other Classes (n = 175)		Tested Class (n = 60)		t	Prob.
	Mean	S.D.	Mean	S.D.		
ACT						
English	15.2	4.60	14.8	4.64	0.48	0.631
Mathematics	13.7	7.09	13.0	5.81	0.75	0.455
Social Studies	14.3	5.90	14.0	5.98	0.32	0.748
Natural Science	18.4	5.37	16.7	5.40	2.16	0.032
Composite	15.5	4.44	14.8	4.33	1.12	0.262
High School GPA	2.50	0.52	2.35	0.59	1.94	0.053
Attitudes Toward Mathematics						
Perception of the Mathematics Teacher	23.2	3.61	23.6	3.79	-0.78	0.434
Anxiety Toward Mathematics	16.9	4.44	17.2	4.01	-0.57	0.568
Value of Mathematics in Society	26.0	3.43	25.4	3.73	0.99	0.322
Self-Concept in Mathematics	21.8	4.41	21.0	3.46	1.27	0.206
Enjoyment of Mathematics	21.3	4.29	20.5	3.88	1.21	0.228
Motivation in Mathematics	20.7	3.10	20.4	3.56	0.68	0.500

Hotelling's T^2 = 15.6648

F-value = 1.2438, df = 12, 222, $p = 0.254$

that the selected students were significantly different from the others, and it was deemed that they were reasonable candidates to receive the Final Examination as a pretest.

The average score on the pretest for the 60 students who completed the class was 8.4 on the 33-item test. The high score was 19; the low score was 4. Since the chance score for a 33-item, four-choice exam is 8.25, the class average was considered a chance score on the test, representing very little knowledge of the subject matter.

The posttest consisted only of the Business Mathematics Final Examination. It was administered by the instructors in the lecture classes during the last week of the term. Instructors administered the test in the programmed sections as students completed the course requirements. Those not finished before the end of the term completed the test on the last class day.

Statistical Processing

Data Entry

A computer-based record for each student was developed. The data were maintained under the author's ID on the interactive terminal system (MUSIC) used by the IBM 4381 mainframe computer at Ferris State College. In addition, an estimated gain score was computed for all students by using a data-transformation option within the processing program.

The name, social security number, ACT scores, and final grade were transferred from the student master file to a user's file at the conclusion of the course. The remainder of the data were entered via

the keyboard by Testing Office personnel at Ferris State College. Following data entry, the accuracy was verified by visual inspection of the file contents and the original document.

Analysis Programs

The data were analyzed by the BMDP statistical package on the Ferris State College mainframe computer. The BMDP programs are a recognized resource for processing social science data (Iverson & Norpath, 1976; Tabachnik & Fidel, 1983). Statistics computed for the purpose of this study were (1) frequency distributions, means, and standard deviations (BMDP2D); (2) Hotelling's T^2 and t-tests (BMDP3D); (3) Bartlett's test for homogeneity of variances and equality of cell frequencies (BMDP9D); (5) analysis of variance and covariance (BMDP2V); and (6) correlational analysis and stepwise multiple regression (BMDP2R).

CHAPTER IV

FINDINGS

The study was designed to evaluate the effectiveness of the lecture and programmed, self-paced instructional methodologies in the Business Mathematics 121 course at Ferris State College. Five evaluative questions concerned with (1) the continuation of offering two methods, (2) sectioning by ability level, (3) prerequisite learning experiences, (4) attitudinal assessment, and (5) student evaluation of instruction were raised. The methodology and evaluative criteria were presented in the previous chapter. The statistical analysis was guided by the research questions, which are restated as hypotheses in this chapter. The statistical treatment required that the data meet certain requirements.

Data-Collection Results

A total of 112 students completed the lecture instruction, and 123 students completed the programmed instruction. The ACT measures, mathematics attitude measures, mathematics background measures, and the final course grade were collected for all students. However, four lecture method students and ten programmed method students who received failing grades declined to take the final examination. Missing data on an important dependent variable present a dilemma of throwing out cases

and collected data or introducing contrived scores. A procedure recommended by Tabachnik and Fidell (1983) was used here. The cases with missing data were kept in the data set by using the following procedure. Within each instructional group, the mean final score for the failing students who took the Final was computed. Respectively, these means were inserted in the student's record to substitute for the missing data. Then, a stepwise multiple regression was executed for each method using the final examination as the dependent variable. The resultant equations were then used to predict a new final test score. The predicted scores were substituted for the means. Then, the regression process was repeated to assure that the revised final test score was identical to predicted test score.

Five students from each instructional method did not complete the course methodology survey. The evaluative survey data did not lend themselves to the same kind of missing-data treatment as the achievement data. Consequently, the student survey analysis was based on 107 lecture and 118 programmed students.

Verification of Assumptions

Similarity of students' characteristics in the two instructional methods was a primary assumption requiring verification or manipulation of the data to attain equality. In addition, the analysis of variance statistical procedure required that assumptions about equality of cell frequencies and homogeneity of variance be met before data analysis (Tabachnik & Fidell, 1983).

Pretest Equality

Pretest data were obtained from student records, ACT test scores, a Mathematics Attitude Survey, and from the Business Mathematics Questionnaire. The ACT and attitudinal measures were continuous variables, while the questionnaire included categorical variables.

Continuous variables. There were 112 students who completed the lecture treatment and 123 who completed the programmed treatment (Table 4.1). The withdrawals from the course were proportional with 26 (19 percent) leaving the lecture treatment and 30 (20 percent) leaving the programmed treatment. Pretest equality was analyzed with a multivariate test, Hotelling's T^2 (Tabachnick & Fidell, 1983). The F-value for the test was 1.211 and had a probability level of 0.276; thus the two groups were acceptably similar. Closer inspection of the probabilities for the individual variables revealed that a significant difference was observed on the ACT Social Studies test. Also, the probability associated with the mathematics test was near significance. Although the multivariate test implied that the significant difference may well have been a chance difference, a Type I error, it was decided to consider the social studies test as a covariate in the analysis of variance test. However, the homogeneity of regression requirement for analysis of covariance could not be met. Consequently, two-way analysis of variance (aptitude group by method) was used.

The mathematics test score was positively correlated with the social studies test ($r = 0.35$) and was used as the blocking variable in the analysis of variance, thus reducing the potential influence of the

Table 4.1.--Comparison of pretest ability and attitude measures for business mathematics teaching methodologies.

Measure	Lecture (n=112)		Programmed (n=123)		t	Prob.
	Mean	S.D.	Mean	S.D.		
ACT						
English	15.2	4.31	15.0	4.88	+0.34	0.734
Mathematics	12.7	7.04	14.3	6.47	-1.81	0.072
Social Studies	13.4	5.88	14.9	5.86	-2.00	0.047
Natural Science	17.6	5.19	18.3	5.63	-0.93	0.350
Composite	14.9	4.30	15.8	4.49	-1.57	0.119
High School GPA	2.5	0.55	2.5	0.54	0.15	0.877
Attitudes Toward Mathematics						
Perception of Mathematics Teacher	23.0	3.64	23.6	3.66	-1.23	0.220
Anxiety Toward Mathematics	17.1	4.58	16.8	4.09	0.50	0.616
Value of Mathematics in Society	25.6	3.74	26.0	3.29	-0.74	0.461
Self-Concept in Mathematics	21.7	4.53	21.6	3.88	0.31	0.757
Enjoyment of Mathematics	21.1	4.30	21.1	4.10	0.09	0.927
Motivation in Mathematics	20.6	3.18	20.7	3.26	-0.36	0.716

Hotelling's $T^2 = 15.26$
F-value = 1.211, df = 12, 222, p = 0.276

social studies variable. Tabachnick and Fidell (1983) stated that blocking is a useful technique for reducing the effect of pretest differences where random assignment of subjects to experimental treatments is not possible.

Although the ACT means were below those for Ferris State College students in general, it was probable that the score distributions overlapped considerably. When compared to Ferris students in mathematics ability, the business mathematics students were underrepresented in the upper part and overrepresented in the lower part of the score distribution. A chi-square goodness-of-fit test (Ferguson, 1966) produced a significant value of 24.16. The critical value for 5 degrees of freedom at the .01 level was 15.09. No college-wide data were available for mathematics attitudes.

Categorical variables. The categorical variables from the Background Questionnaire were examined with the use of chi-square tests (Table 4.2). Although not statistically significant, it appears that the programmed method included a slightly higher proportion of freshman students.

The students were highly similar in the amount of high school and college mathematics in their backgrounds. Twenty-seven students had completed general mathematics (Mathematics 090) and almost one-half had completed the first course in the algebra sequence (Mathematics 111). Slightly over one-third completed the first course in college algebra (Mathematics 121), and a small group had completed advanced mathematics.

Table 4.2.--Comparison of demographic data for business mathematics teaching methodologies.

Measure	Lecture		Programmed		Combined	
	Freq	Pct	Freq	Pct	Freq	Pct
College						
Freshman	63	26.8	76	32.3	139	59.2
Sophomore	27	11.5	37	15.7	64	27.2
Junior	17	7.2	6	2.6	23	9.8
Senior	5	2.1	4	1.7	9	3.8
Total	112	47.7	123	52.3	235	100.0
Chi-square = 7.65, df = 3, p = 0.054						
High School Math Semesters						
One or two	38	16.2	26	11.1	64	27.2
Three or four	39	16.6	52	22.1	91	38.7
Five or six	19	8.1	29	12.3	48	20.4
Seven or more	16	6.8	16	6.8	32	13.6
Chi-square = 5.69, df = 3, p = 0.128						
College Mathematics Courses						
Zero	19	8.1	19	8.1	38	16.2
One	63	26.8	66	28.1	129	54.9
Two	25	10.1	27	11.5	52	22.1
Three	4	1.7	7	3.0	11	4.7
Four or more	1	0.4	4	1.7	5	2.1
Chi-square = 1.89, df = 3, p = 0.596						
College Mathematics Enrollment						
General Mathematics						
Yes	14	6.0	13	5.5	27	11.5
No	98	41.7	110	46.7	208	88.5
Chi-square = 0.25, df = 1, p = 0.643						

Table 4.2.--Continued.

Measure	Lecture		Programmed		Combined	
	Freq	Pct	Freq	Pct	Freq	Pct
Algebra I						
Yes	55	23.4	57	24.3	112	47.7
No	57	24.3	66	28.1	123	57.3
Chi-square = 0.18, df = 1, p = 0.672						
College Algebra						
Yes	36	15.3	49	20.9	85	36.2
No	76	32.3	74	31.5	150	63.8
Chi-square = 1.50, df = 1, p = 0.22						
Above College Algebra						
Yes	10	4.3	17	7.2	27	11.5
No	102	43.4	106	45.1	208	88.5
Chi-square = 1.38, df = 1, p = 0.24						
Sex						
Male	42	17.9	56	23.8	98	41.7
Female	70	29.8	67	28.5	137	58.3
Chi-square = 1.55, df = 1, p = 0.213						
Field of Study						
Business--OA	26	11.0	9	3.8	35	14.9
Business--Non-OA	67	28.5	93	39.6	160	68.1
Nonbusiness	19	8.2	21	8.9	40	17.0
Chi-square = 12.21, df = 2, p = .001						

The sex ratio was balanced between the two groups, although the pattern was the reverse of that of Ferris students generally. Males make up 60 percent and females 40 percent of the college student population. The opposite ratio was present here.

A distinct difference was observed between the two methods in the students' field of study. Students from the office administration curriculum were underrepresented in the programmed method, and students from other business majors were underrepresented in the lecture method. The differences were significant beyond the 0.01 level.

Summary. The multivariate test on the continuous variables and the chi-square tests on eight of nine categorical variables demonstrate that the lecture and programmed groups were statistically similar to each other.

Assumptions for Analysis of Variance

Assumptions for analysis of variance are based on independence, equality of cell frequencies, and homogeneity of variance.

Independence. Representativeness of subjects in treatment groups satisfies the independence assumption. Data from the multivariate test and chi-square test previously reported (Table 4.1) reveal the independence of the students within the instructional groups.

Equality of cell frequencies. Four aptitude groups were formed from the combined score distributions on the ACT Mathematics test. The divisions were selected to represent the ACT Math quartiles as closely as possible. The Low-ability group included ACT Mathematics scores

from 01 to 08, the Mid-Low group included scores from 09 to 12, the Mid-High group included scores from 13 to 19, and the High-ability group included scores from 20 to 32 (Table 4.3). The chi-square test of independence for equality of cell frequencies produced a nonsignificant value, thus supporting equality.

Table 4.3.--Test of assumptions for analysis of variance.

Groups	N	Final Examination	
		Mean	S.D.
High Ability			
Lecture	25	24.5	7.02
Programmed	34	27.5	4.47
Upper-Mid Ability			
Lecture	27	23.7	5.64
Programmed	32	25.2	5.32
Lower-Mid Ability			
Lecture	23	19.7	4.02
Programmed	32	24.0	4.86
Low Ability			
Lecture	37	21.4	4.50
Programmed	25	19.3	4.30

Chi-square = 6.06, df = 7, p = 0.533
F = 1.84, df = 7,227, p = 0.075

<u>Homogeneity of variance</u>. Bartlett's test for homogeneity of variance was used to test the homogeneity of the cell variances on the dependent variable, the Final Examination. The probability associated with the F-value of 1.84 was 0.075, near but not reaching significance.

The standard deviations for the lower three ability groups appeared quite similar. The greatest difference existed within the upper ability group, where the ratio of the standard deviations is less than two to one.

The pattern of equality observed in the pretest data was supported by the test for equality of cell frequencies and homogeneity of variance. Consequently, the application of analysis of variance for comparative purposes was valid.

Analysis of Research Questions

The findings for the research questions are presented below. To support the presentation, the questions are restated as null hypotheses to aid the clarity of the discussion.

Achievement Gain for Two Methodologies

The evaluative question was: Should the offering of both lecture and programmed instructional methodologies be continued? The question had two aspects, one comparing the estimated achievement gain for each method to no gain, and the other comparing the respective gains to each other.

> Hypothesis 1a: The estimated mean gain score for the lecture method is not significantly different from zero (MgL = 0).

The mean lecture posttest score was 22.3 and the estimated mean gain was 13.9 points (Table 4.4). The t-value was very high and did not register a probability level in the fourth decimal position.

Consequently, the gain score was significantly different from zero and Null Hypothesis 1a was rejected (H1a:MgL≠0).

<u>Hypothesis 1b</u>: The estimated mean gain score for the programmed method is not significantly different from zero (MgP=0).

The mean programmed posttest score was 24.3 and the estimated mean gain was 15.9 points. As with the lecture gain, the t-value was quite high and statistically significant. Consequently, the gain score was significantly different from zero and Null Hypothesis 1b was rejected (H1b:MgP≠0).

Table 4.4.--Gain score t-tests for instructional methods.

Method	N	Posttest		Gain		t-value	Prob.
		Mean	S.D.	Mean	S.D.		
Lecture	112	22.3	5.58	13.9	5.58	26.3	0.000
Programmed	123	24.3	5.47	15.9	5.47	32.3	0.000
Difference				2.0	1.01[a]	1.98	0.043

[a]Standard error.

<u>Hypothesis 1c</u>: The difference between the estimated mean gain scores for the two methodologies is not significantly different from zero (Mg(L-P)=0).

The difference between the methods was 2.0 points, and the standard error for the difference between the means was 1.01. However, the appropriate test of significance was a two-way ANOVA, which provided control over the aptitude groups as well as method (Table 4.5).

The F-value for treatment was 6.51, and the probability level was 0.011. Consequently, the null hypothesis was rejected (H1c:Mg(L-P)≠0). There was a statistically significant difference in pre- to posttest gain for the programmed method compared to the lecture method of instruction. The full implication of this finding required the analysis of the following research question.

Table 4.5.--Analysis of variance components for Final Examination scores in business mathematics.

Effect	SS	df	MS	F	Prob.
Mean	122689.31	1	122689.31	4839.82	0.000
Aptitude--ACT Math	1120.19	3	373.40	14.73	0.000
Treatment--lecture/prog.	165.01	1	165.01	6.51	0.011
Interaction	328.24	3	109.41	4.32	0.006
Residual	5754.44	227	25.35		

Sectioning by Ability

The evaluative question was: Should sectioning by ability levels be initiated for the different instructional methodologies? The question implied that the respective aptitude groups should perform equally well to maintain the current practice of not sectioning. Unequal performance for equal ability groups would support a recommendation for sectioning. The question called for an analysis of aptitude-treatment interaction.

Hypothesis testing for ATI. The null hypotheses were that the difference between the final test scores would not be significantly different from zero for the aptitude groups. An analysis of variance as performed to test the hypothesis (Table 4.5).

> Hypothesis 2a: The difference between the mean Final test scores for the High-aptitude lecture and programmed groups is not significantly different from zero (MhL-MhP=0).

> Hypothesis 2b: The difference between the mean Final test scores for the Mid-High aptitude lecture and programmed groups is not significantly different from zero (MmhL-MmhP=0).

> Hypothesis 2c: The difference between the means for Final test scores for the Mid-Low aptitude lecture and programmed groups is not significantly different from zero (MmlL-MmlP=0).

> Hypothesis 2d: The difference between the means for Final test scores for the Low-aptitude lecture and programmed groups is not significantly different from zero (MlL-MlP=0).

The F-test for treatment ($F = 6.51$, $p = 0.011$) revealed that a significant difference in performance existed (Table 4.6). The differences between the means and the 95 percent confidence intervals for Scheffe's post hoc comparisons (Glass & Stanley, 1970) were computed (Table 4.6). The null hypotheses for the Mid-High and Low aptitude groups were not able to be rejected (H2b: MmhL-MmhP=0 and H2d: MlL-MlP=0). However, the null hypotheses for the High- and Mid-Low aptitude groups were rejected (H2a: MhL-MhP≠0 and H2c: MmlL-MmlP≠0). In both of the latter comparisons, the programmed method students demonstrated superior achievement.

Table 4.6.--Post-hoc comparisons for aptitude by treatment interactions for Final test scores in business mathematics.

Aptitude	Lecture			Programmed			Mean Diff.	Limits	95% Confidence Interval
	N	Mean	S.D.	N	Mean	S.D.			
High	25	24.5	7.02	34	27.5	4.47	-3.0*	±2.57	- .43 to -5.57
Mid-High	27	23.7	5.64	32	25.2	5.32	-1.5	±2.55	1.05 to -4.05
Mid-Low	23	19.7	4.02	32	24.0	4.86	-4.3*	±2.68	-1.62 to -6.98
Low	37	21.4	4.50	25	19.3	4.30	+2.1	±2.53	4.63 to -0.43

*Difference outside the 95 percent confidence interval.

These findings provided mixed results with respect to sectioning decisions. The former practice of placing the two Mid-level aptitude groups in the lecture treatment was not supported. For the Mid-High group the difference was not significant, but it favored the programmed method. For the Mid-Low group, the difference was significant and it favored the programmed method.

The former practice of placing the High- and Low-aptitude groups in the programmed method received only partial support. The High-aptitude group achieved better in the programmed method, upholding past practice. The lowest scoring group was the Low-aptitude programmed method group; hence, the former practice for this subgroup was not supported. The F-test for interaction ($F = 4.32$, $p = 0.006$) revealed that a significant interaction existed. The nature of the interaction can be observed by inspecting the Final Test means for the respective aptitude groups (Figure 4.1).

It was apparent that the means for the programmed group conformed to a hierarchical expectation, while the means for the Low lecture and Mid-Low lecture groups were reversed. Koran (1974) described this type of interaction as disordinal. The instructional implication for this type of finding is that the Low students should be placed in the lecture treatment and the Mid-Low students should be placed in the programmed treatment. While it might be possible to find explanations for superior performance for Low students in the lecture method over the programmed method, the superior performance of the Low

over the Mid-Low students in the lecture group seemed inexplicable. Hence, further exploration of the data was undertaken.

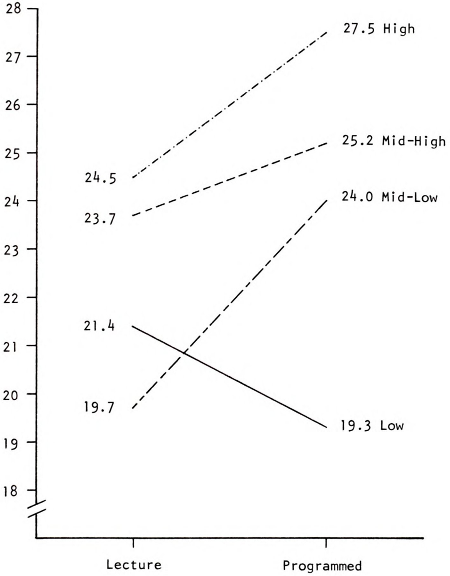

Figure 4.1.--Means for the Final test scores.

Interaction exploration of grades. First, the final course grades were put into the same ANOVA procedure as the Final Test Scores (Table 4.7). The F-test for interactions produced a value of 4.84, and the probability level exceeded 0.003.

Table 4.7.--Analysis of variance components for Final grades in business mathematics.

Effect	SS	df	MS	F	Prob.
Mean	970.15	1	970.15	965.82	0.000
Aptitude--ACT Math	75.82	3	25.27	25.16	0.000
Treatment--lecture/prog.	2.17	1	2.17	2.16	0.143
Interaction	14.60	3	4.86	4.84	0.003
Residual	228.02	227	1.00		

Serendipitous exploration of attitudes. The lack of adequate explanations for the above findings led to an analysis of the attitudinal measures under the assumption that more complete inspection of the aptitude groups was warranted. Each of the six attitudinal measures was assigned as a dependent variable in the two-way analysis of variance. Four of the six variables revealed no interaction to help explain the achievement pattern. However, the Motivation scale produced a significant F-test value for interaction ($F = 3.27$, $p = 0.014$) (Table 4.8). The Motivation attitude means for the aptitude groups

were graphically similar to those of the posttest achievement means (Figure 4.3). At the time of pretesting, the Low group in the lecture method reported higher motivation than both the Mid-Low and Mid-High groups. Reasons for this phenomenon are not known.

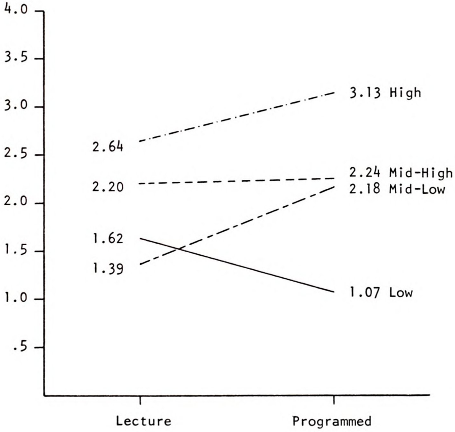

Figure 4.2.--Means for Final grades.

Table 4.8.--Analysis of variance components for Motivation in Mathematics attitudinal scale.

Effect	SS	df	MS	F	Prob.
Mean	96830.00	1	96830.00	9685.93	0.000
Aptitude--ACT Math	67.22	3	22.41	2.24	0.084
Treatment--lecture/prog.	1.17	1	1.17	0.12	0.733
Interaction	98.03	3	32.68	3.27	0.022
Residual	2214.77	227	9.80		

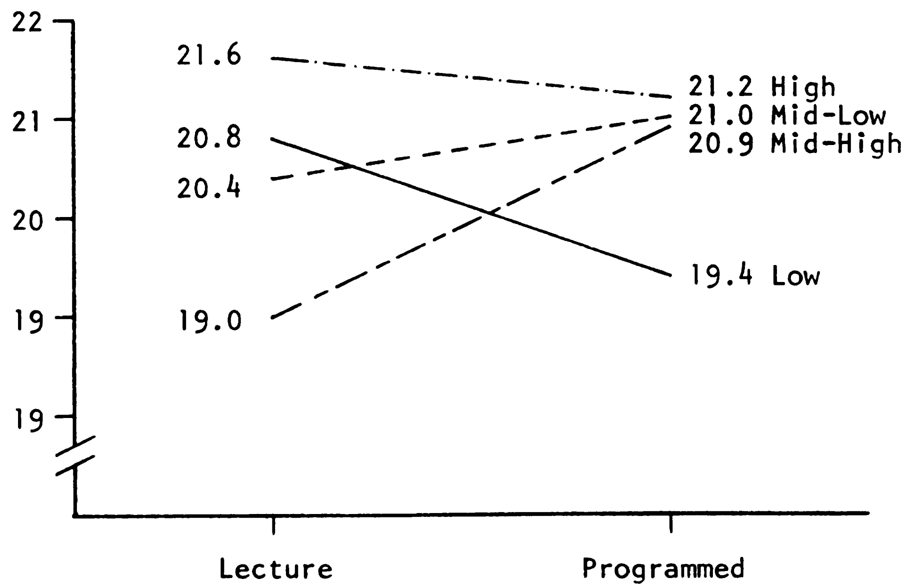

Figure 4.3.--Means for Motivation in Mathematics.

Although the interaction was not significant (Table 4.9), the Enjoyment of Mathematics scale produced (Figure 4.4) a pattern highly similar to that of the Motivation scale and the achievement measures.

Table 4.9.--Analysis of variance for Enjoyment of Mathematics attitudinal scale.

Effect	SS	df	MS	F	Prob.
Mean	101308.06	1	101308.06	6279.00	0.000
Aptitude-- ACT Math	426.77	3	142.26	8.82	0.000
Treatment-- lecture/prog.	3.31	1	3.31	0.21	0.651
Interaction	41.59	3	13.86	0.86	0.460
Residual	3662.51	227	16.13		

Attitudes as covariates. Pretest differences in attitudes were camouflaged in the total score distribution (Table 4.1). Significant differences were not evident. Also, the correlations with achievement (r = .12 and r = .26) were not high, yet the attitudes appeared to be a pretestable characteristic of Low and Mid-Low students that helped explain achievement outcomes.

Summary. It appeared that High-ability students benefit from the programmed instruction. Beyond that clear finding, it appeared that the hypotheses, as stated, failed to account for the complexity represented by the data. Without the serendipitous findings about the

attitude patterns of the Mid-Low and Low groups, faculty conclusions about aptitude-treatment interactions could have been reached.

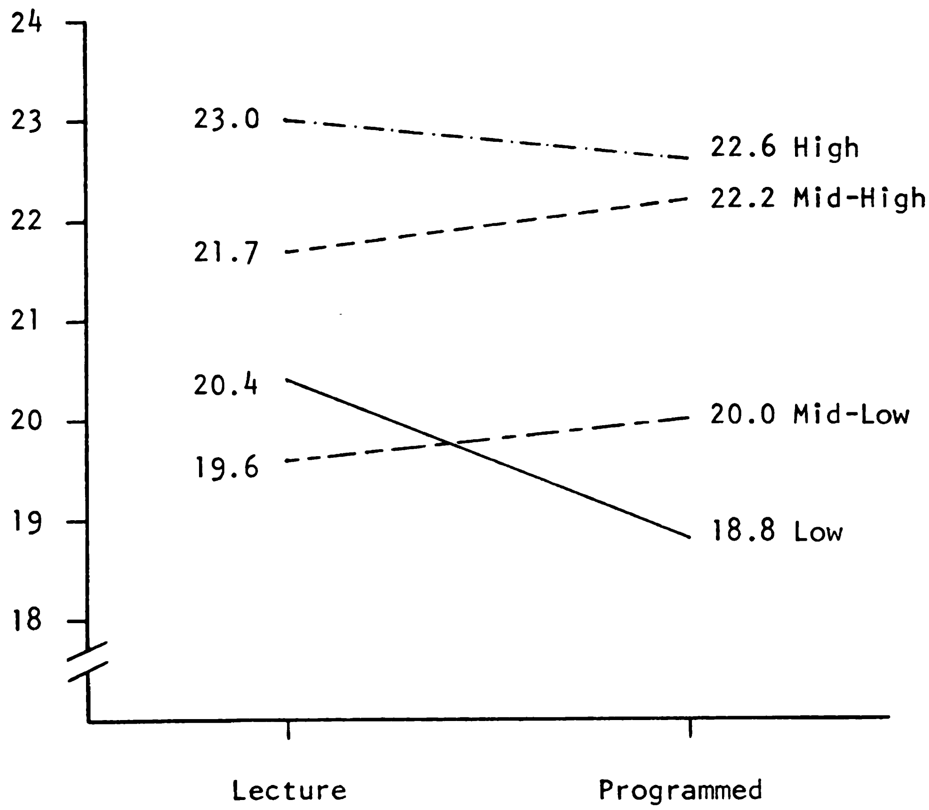

Figure 4.4.--Means for Enjoyment of Mathematics.

What appeared to be a differential effect of instructional method on the lower half of the ability group was a reflection of pretest attitudinal differences. Reasons why students with low ability, but higher motivation and Mid-High ability, but lower motivation were enrolled in the lecture treatment and not enrolled in the programmed treatment were not available. Perhaps advice students

received from advisors and fellow students was a factor, or the phenomenon was unique to this study. Only a repetition of this study could suggest which explanation is most plausible. Obviously, future studies should include attitudinal measures and subgroup analysis techniques. Further study of this phenomenon is recommended.

Prerequisite Learning

The research question was: Should a prerequisite learning experience be established for students with low mathematical ability? The college adopted a practice of recommending mathematics course placement to students who had an 80 percent chance or better of earning "C" or higher grades. However, this criterion has not been applied to business mathematics.

The number and proportion of students from each method who earned "C-" or higher grades based on ACT Mathematics scores were combined into 13 score categories (Table 4.10). Overall, 164 students or 70 percent received at least "C-" grades. The 80 percent criterion for score levels was reached in the score interval for 17 and 18. The criterion implied that 148 students or 63 percent would be candidates for a prerequisite experience. This finding was unexpected, especially since a high proportion had taken college mathematics courses previously.

The low probability of success suggested an analysis of student achievement based on prior enrollment in a mathematics course be performed. Based on current Ferris State College practice, students with

scores from 01 to 08 are recommended to take Mathematics 090, a course that emphasizes arithmetic skills and concepts.

Table 4.10.--Frequency and proportion of students earning C- or higher final grades in Business Mathematics 121.

ACT Math Score Interval	Frequency and Proportion Earning C- or Higher								
	Lecture			Programmed			Combined		
	Freq	Total	Prop	Freq	Total	Prop	Freq	Total	Prop
27-above	3	3	100	1	1	100	4	4	100
25-26	2	2	100	4	4	100	6	6	100
23-24	3	3	100	10	10	100	13	13	100
21-22	8	10	80	12	12	100	20	22	91
19-20	11	13	85	8	9	88	19	22	86
17-18	7	8	86	11	12	92	18	20	90
15-16	5	7	71	8	13	62	13	20	65
13-14	4	6	66	4	5	80	8	11	73
11-12	4	8	50	11	15	73	15	23	65
9-10	5	15	33	14	17	82	19	32	60
7-8	5	10	50	3	10	30	8	20	40
5-6	11	16	68	3	11	27	14	27	52
1-4	5	11	45	2	4	50	7	15	47
Total	73	112	65	91	123	74	164	235	70

Effect of Mathematics 090. Student final grades and final test scores for those who took Mathematics 090 compared to those who were not enrolled in another mathematics course suggested that the relationship between enrollment in a recommended prerequisite course and success in business mathematics was random (Table 4.11). In fact, inspection of the data suggested that students without Mathematics 090 were slightly more successful in avoiding "F" grades and low final test scores in the subsequent business mathematics class. Thus, it appeared that

Mathematics 090 was not an effective prerequisite course for students whose ACT Mathematics scores were in the 01 to 08 range.

Table 4.11.--Comparison of success in business mathematics based on prior enrollment in Mathematics 090 for the 1 to 8 score range.

Final Grades	Enrolled		Not Enrolled	
	Freq	Pct	Freq	Pct
A	0	00.0	1	2.4
B	3	14.3	5	12.2
C	5	23.8	15	36.6
D	7	33.3	13	31.7
F	6	28.6	7	17.1
Total	21	100.0	41	100.0

Chi-square = 1.59, df = 3, p = 0.661
r = -0.129

Final Test Scores				
28-33	2	9.5	4	9.8
24-27	2	9.5	5	12.2
20-23	5	23.8	18	43.9
7-19	12	57.2	14	34.1
Total	21	100.0	41	100.0

Chi-square = 3.318, df = 2, p = 0.190
r = -0.130

Effect of Mathematics 111. A similar analysis for students with ACT Mathematics scores in the 09 to 17 range was also performed (Table 4.12). The Mathematics 111 course, Introductory Algebra, is the course to be recommended routinely to students in this ability range. Those who had enrolled versus those who did not were compared on both success

measures, final grades and final test scores. No relationship existed between prerequisite course enrollment and success in the business mathematics course. The chi-square values were small, and the corresponding probabilities were large. Thus, it appeared that Mathematics 111 was not an effective prerequisite for students whose ACT Mathematics scores were in the 09 to 17 range.

Table 4.12.--Comparison of success in business mathematics based on prior enrollment in Mathematics 111 for the 9 to 17 score range.

Final Grades	Enrolled		Not Enrolled	
	Freq	Pct	Freq	Pct
A	5	7.7	4	12.1
B	16	24.6	9	27.7
C	21	32.3	11	33.3
D	14	21.6	5	15.2
F	9	13.8	4	12.1
Total	65	100.0	33	100.0

Chi-square = 1.045, df = 4, p = 0.903
r = -0.087

Final Test Scores	Freq	Pct	Freq	Pct
28-33	15	23.1	7	21.2
24-27	18	27.7	8	24.2
20-23	15	23.1	9	27.3
7-14	17	26.1	9	27.3
Total	65	100.0	33	100.0

Chi-square = 0.300, df = 3, p = 0.960
r = 0.035

Effect of Mathematics 121. A third analysis was made for students whose ACT Mathematics scores were in the 18 to 22 range and who enrolled in Mathematics 121, College Algebra. Mathematics 121 experience had a positive effect on business mathematics achievement (Table 4.13). On the final grades measure, the chi-square value was 4.993 and the corresponding probability of 0.082 approached significance. The proportions earning "A" or "B" grades differed by 26.8 percent, favoring those who enrolled in Mathematics 121. On the final test, the data produced a significant difference. The chi-square value was 9.483 and the associated probability was 0.024. An inspection of the table shows scores of 20 and above were achieved by a high proportion of students who had enrolled in Mathematics 121, and a higher proportion of those who did not enroll scored 19 or fewer points on the Business Mathematics Final Examination. Thus, it appeared that enrollment in Mathematics 121 was associated with better performance in business mathematics.

Table 4.13.--Comparison of success in business mathematics based on prior enrollment in Mathematics 121 for the 18 to 22 score range.

Final Grades	Enrolled		Not Enrolled	
	Freq	Pct	Freq	Pct
A	9	27.3	1	5.3
B	12	36.4	6	31.6
C	10	30.3	8	42.1
D	2	6.0	2	10.5
F	0	0.0	2	10.5
Total	33	100.0	19	100.0

Chi-square = 4.993, df = 2, p = 0.0824
r = 0.356

Final Test Scores				
28-33	14	42.4	6	31.6
24-27	9	27.3	5	26.3
20-23	8	24.3	1	5.3
7-19	2	6.0	7	36.8
Total	33	100.0	19	100.0

Chi-square = 9.483, df = 3, p = 0.024
r = 0.232

Summary. The failure of the plausible prerequisite courses to be associated with better achievement in the business mathematics course for students who scored 17 and below on ACT Mathematics is a matter of concern. Several possibilities for this phenomenon could be investigated.

1. Students in the 01 to 17 ability range may have difficulty with transference of learning.

2. The mathematics course content may be paced inappropriately for students of this ability level. Perhaps more time is needed.

3. The ACT Mathematics score cut-off points for course placement may require upward adjustment, giving students with scores of 09 and 10 the opportunity to take Mathematics 090 before taking the Algebra course.

4. Business mathematics instruction may include compensatory instruction which is sufficient to negate the effects of the mathematics courses on business mathematics achievement.

5. The business mathematics course may be more difficult conceptually than previously perceived. Instead of being a step up from Mathematics 090 and on a level with Mathematics 111, it may be a step up from Mathematics 111 and on a level with Mathematics 121.

All of the above may interrelate to explain the results observed. Further study of alternatives is recommended.

Attitude Assessment

The research question was: Should attitudes toward mathematics be considered with ability measures in course-sectioning decisions? The criterion for accepting attitudinal measures was a significant contribution in the explanation of the variance of the dependent variable after the ability measures had been fully used. The Final course grade was selected as the dependent variable because most of the independent variables had slightly higher correlations with the grade than with the final test score.

Results. Stepwise multiple regression was applied to the data of the 235 students from the combined treatment groups. The hierarchical regression was controlled to first allow the entry of the ability measures before accepting the attitudinal measures. The F-to-enter level (0.50) was selected to permit the full use of the ACT tests and high school grades before considering attitude measures (Tabachnick & Fidell, 1983). The maximum number of steps in the regression was set at eight; however, five steps proved to be sufficient.

The primary predictor in the multiple regression analysis was the ACT Mathematics test, which accounted for 26 percent of the variance in grades (Table 4.14). The high school grade point and two ACT test variables, Social Studies and English, were selected next by the statistical procedure. The F-value associated with the grades was significant at the .01 level, and the F-value associated with the Social Studies measure was significant at the .05 level. The contribution of the English test was not significant, but its presence exhausted the contribution of the ability measures. Also, the presence of the Social Studies and English tests was a reminder about the verbal aspects of mathematical achievement.

The attitudinal measure, Self-Concept in Mathematics, was entered in the fifth step. Its contribution added 4 percent to the explanation of variance in achievement as measured by course grades. The cumulative explanation of variance was .3871 or 39 percent. The F-value associated with Self-Concept in Mathematics was 16.1457. To satisfy the research question, the critical F-value at the .01 level of

confidence for 1 and 229 degrees of freedom was 6.76. The observed F-value for the attitude measure was well beyond the .01 level; thus the stipulated criterion for accepting the use of attitudinal data in course sectioning was met.

Table 4.14.--Prediction of final grades using ability and attitude measures for lecture and programmed students combined.

Step No.	Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F-to Enter
1	ACT Math	0.5064	0.2564	0.2564	80.3493
2	HS GPA	0.5725	0.3277	0.0713	24.6033
3	ACT Soc Stu	0.5848	0.3420	0.0143	5.0040
4	ACT English	0.5864	0.3439	0.0019	0.6690
5	Self-Concept	0.6222	0.3871	0.0432	16.1457

Other variables. At the conclusion of the fifth step in the regression, the partial correlations and F-values for the other attitudinal measures and sex were inspected. All were within the chance region, well below the critical F-value of 3.89 at the .05 level. For example, the largest F-value was 1.056 for the motivation measure. The F-value for the demographic variable Sex was 0.37.

Multivariate procedure. If an attitudinal assessment were implemented, the instrument could be administered in the college's new student orientation program. The students' responses could be scanned and passed to the mainframe computer electronically. A scoring program, now in use, could be used to derive scores for inclusion in the student master file along with ACT test scores and high school grades.

The scores could be processed by the formula generated from the multiple regression procedure to attain a predicted course grade. The formula is:

Predicted Grade = -1.807 + .049*(ACT Math) + .472*(HS GPA) + .025*(ACT SS) + .023*(ACT ENG) + .063*(Self-Concept)

The predicted grade could be translated into a placement recommendation and printed on the college's placement profile to accompany course placement suggestions in other subject course areas, such as mathematics, English, and reading development.

Use of attitude assessment for Low-ability students. Prior analysis of aptitude-treatment interactions in the discussion on sectioning decisions revealed that two attitude measures, Motivation in Mathematics and Enjoyment of Mathematics, had a special relationship to achievement in the lecture group. The Mid-Low aptitude group had a low motivation, low enjoyment of mathematics, and low achievement pattern, while the lowest aptitude group had higher motivation, enjoyment, and higher achievement. This reversal was not evident for the programmed group.

Also, the analysis of prerequisite learning (Table 4.9) revealed that Low and Mid-Low lecture groups had relatively low probabilities of "C-" or better grades. In comparison, the Mid-Low programmed group had a higher proportion earning grades of "C-" or better. Given those contrasts, it seemed useful to explore the role of

the attitudinal variables in explaining achievement for these lower aptitude students within the respective treatment groups.

For this analysis, stepwise multiple regression was applied to each instructional group. In contrast to the prior regression for the total group, the restriction to enter ability measures was first removed. The attitudinal and demographic measures had equal opportunity to be considered. In each case, a stepwise regression was run; the table of partial correlations was inspected at each step. An optimal set of predictor variables was selected for inclusion.

The stepwise multiple regression for 60 students from the lower half of the aptitude distribution in the lecture method showed that across the eight steps 30 percent of the variance in grades was explained by all predictor variables (Table 4.15). The contribution of individual measures after the second step was not significant at the .05 level. However, the F-ratio for the overall regression at the eighth step was 2.71, significant at the .05 level for 8 and 51 degrees of freedom.

Setting aside the matter of significance, it was interesting to observe the role attitudes played in this analysis. The primary predictor, Enjoyment of Mathematics, accounted for 8 percent of the variance. It was followed in Step 2 by the English Usage measure, not Mathematics or High School Grades. Then the Value of Mathematics measure was entered, followed by Natural Science and two more attitudinal measures, Anxiety and Motivation. In all, the attitudinal measures accounted for 14 percent or almost one-half of the total

explained variance. Perhaps the chief value of this analysis of the lecture method is to contrast it with the same aptitude group that experienced the programmed method.

Table 4.15.--Stepwise multiple regression of ability and aptitude and demographic measures on grades for the lower aptitude students in the lecture method.

Step No.	Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F-to Enter
1	Enjoyment	0.2878	0.0828	0.0828	5.2384
2	ACT Eng	0.4599	0.2115	0.1287	9.3038
3	Value	0.4896	0.2397	0.0281	2.0718
4	ACT NS	0.5098	0.2599	0.0202	1.5048
5	Anxiety	0.5247	0.2753	0.0154	1.1439
6	Motivation	0.5320	0.2831	0.0078	0.5769
7	ACT SS	0.5387	0.2902	0.0072	0.5262
8	Teacher	0.5462	0.2984	0.0081	0.5895

The multiple R for the effect of ability and attitudes on achievement for the programmed method reached .7467 and accounted for 56 percent of the variance in grades in the tenth step for 57 students in the lower-half aptitude group of the programmed method (Table 4.16). The F-value at the tenth step was 10.501, well past the .01 critical value of 3.12 for df = 6,50.

The high school grade point average was entered first and accounted for 27 percent of the variance. The ACT Mathematics and ACT Natural Science variables were entered next. They were followed by the Sex variable, which accounted for an increase of 5 percent in explained grade variance. The coefficient for Sex was negative, meaning the

lower-aptitude women did not use the programmed methods as well as men in the same aptitude range. The F-value associated with Sex, 5.2702, was significant at the .05 level for df = 1,52.

Table 4.16.--Stepwise multiple regression of ability, attitude, and demographic measures on grades for lower-ability students in the programmed method.

Step No.	Variable Entered	Multiple R	Multiple R^2	Increase in R^2	F-to Enter
1	HS GPA	0.5166	0.2669	0.2669	20.0225
2	ACT Math	0.6043	0.3652	0.0983	8.3610
3	ACT NS	0.6364	0.4051	0.0399	3.5523
4	Sex	0.6781	0.4598	0.0547	5.2702
5	ACT NS[a]	0.6643	0.4412	-0.0186	1.7865[a]
6	ACT Math	0.6320	0.3995	-0.4180	3.9632
7	No. HS Math Course	0.6665	0.4442	0.0447	4.2620
8	ACT Math	0.7099	0.5040	0.0598	6.2736
9	Self-Concept	0.7297	0.5325	0.0285	3.1084
10	ACT NS	0.7467	0.5576	0.0251	2.8324

[a]Removed.

In the next four steps, the two ACT tests were removed, the number of high school courses was included, and ACT Mathematics was re-entered. Then the attitudinal measure Self-Concept was entered. The F-value associated with Number of High School Courses was significant at the .05 level; however, the 3 percent contribution of the attitudinal measure was not statistically significant. Similarly, the re-entry of the Natural Science measure was not significant. The effects of attitudes appeared to be negligible in this analysis.

Student Evaluation of Methodology

A seven-item, forced-choice questionnaire designed to obtain student opinions about features of the business mathematics course was administered on the sixth week of the term, before student departures from the self-paced, programmed courses. The first two items asked about the usefulness of the course in developing concepts and skills. The remaining five items asked about opinions of different aspects of the teaching methodologies.

Hypothesis testing. The null hypothesis was that the means of the two methodologies were not significantly different (Hypothesis 3: ML=MP).

One hundred seven students from the lecture group and 118 from the programmed group responded to the course evaluation survey (Table 4.17). Five students were absent from each group. The means for each of the items were within two-tenths of a point from a value of three, which is described by the instrument as agreeing with a positively worded statement. A multivariate test, Hotelling's T^2, produced a value of 9.63 and an associated F-value of 1.338. The probability level for the finding was 0.23, not significant. Thus, the null hypothesis was not able to be rejected (H3: ML=MP).

An inspection of the t-values for each item reveals that one item, concerning use of out-of-class time, produced a significant difference. Research procedure would lead to the conclusion that this finding could be due to chance (Type I error). In contrast, however, the instructional faculty believed that high-ability students who had

the opportunity to depart from class upon completion of the material would report greater satisfaction on this item. Since potential for a Type II error existed, a follow-up analysis was performed.

Table 4.17.--Comparison of student evaluation of teaching methodologies used in business mathematics.

Method	Lecture (n=107)		Programmed (n=118)		t-value	Prob.
	Mean	S.D.	Mean	S.D.		
Understanding of Concepts	3.0	0.62	3.0	0.59	0.01	0.991
Developing Skills	3.1	0.59	3.1	0.63	-0.97	0.336
Like Method	2.9	0.76	3.0	0.88	-1.35	0.179
Adjusted to Method	3.0	0.70	3.0	0.77	-0.55	0.582
Use of In-Class Time	2.9	0.79	3.1	0.77	-1.46	0.146
Use of Out-of-Class Time	2.8	0.71	3.1	0.71	-2.79	0.006
Recommend to Others	3.0	0.80	3.2	0.89	-1.35	0.177

Hotelling's $T^2 = 9.63$
$F = 1.338$, $df = 1,217$, $p = 0.233$

Use of out of class time. The post-hoc comparisons for the four ability groups from each methodology showed that, as suspected by the faculty, the largest mean difference occurred for the High aptitude group (Table 4.18). In fact, within the lecture method the High aptitude group had the lowest mean on the use of out-of-class time, while in the programmed method the High aptitude group had the highest mean. This finding, when considered with the finding that the High aptitude programmed group achieved better than the High aptitude lecture group, provided support for the special placement of the high-ability students in the programmed method.

Table 4.18.--Post-hoc comparisons for aptitude groups on use of out-of-class time in business mathematics.

Aptitude	Lecture			Programmed			Mean Difference
	N	Mean	S.D.	N	Mean	S.D.	
High	23	2.4	0.89	32	3.2	0.55	-0.8
Mid-High	27	2.8	0.74	31	3.0	0.75	-0.2
Mid-Low	20	2.8	0.44	30	3.0	0.79	-0.2
Low	37	3.1	0.55	25	3.1	0.76	0.0

Summary

Student achievement in lecture and programmed classes of Business Mathematics 121 was evaluated in Chapter IV. Pretest data revealed that students enrolled in respective methods had equivalent characteristics and that comparisons between instructional treatments could be pursued. Both methods produced substantial significant gain in knowledge as measured by a pretest administered to a representative group and by a comprehensive final examination.

The programmed method produced higher achievement than did the lecture method, particularly for the High aptitude group. The Low

lecture group achieved better than the Low programmed group, and conversely, the Mid-Low programmed group achieved better than the Mid-Low lecture group. Aptitude-treatment interaction was present. However, additional exploration with the attitude measures revealed a preexisting condition, an attitude-treatment interaction, that cast doubt about the observed aptitude-treatment interaction for the Low aptitude groups.

An analysis of aptitude and course grades revealed that a substantial proportion of the students had less than an 80 percent chance of receiving "C-" or better grades. A number of students had taken potential prerequisite mathematics courses that were considered appropriate for their ability levels. Their performance in Business Mathematics 121 was compared to students of comparable ability levels who had not taken the course. Interestingly, evidence that prior enrollment in a mathematics course had an effect on success in business mathematics was not demonstrated for two of the three groups analyzed. Reasons for this phenomenon were discussed.

The utility of attitude assessment to predict student grades was explored. After ability measures had been entered into stepwise multiple regression, the Self-Concept in Mathematics scale score was entered. It explained 4 percent of the total course variance and was statistically significant. Other attitudinal measures were not useful in predicting success for the combined groups. However, a regression analysis of grade prediction for the Low and Mid-Low aptitude lecture groups revealed that attitude measures accounted for 14 percent, or

about half, of the explained variance. In the equivalent programmed group, sex was significantly related to achievement.

An instrument designed to assess student reaction to the course methodology did not reveal differences between the methods. The multivariate test was not significant; however, the data suggested that High aptitude, programmed method students perceived that the method enabled them to make better use of out-of-class time than did High aptitude lecture students.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Evaluation studies of educational practices are useful to the process of judging the value of such practices and making decisions to improve instructional outcomes. Evaluative studies, like descriptive and experimental studies, generate information useful to future inquiries into the same or similar educational problems. Consequently, this study was designed to evaluate selected aspects of the business mathematics course at Ferris State College.

Two instructional methodologies were used: the self-paced, programmed method and the traditional lecture method. Students who enrolled in the course varied widely in mathematical ability upon entry to the course. Before 1981 these differences were recognized and used to develop sections of homogeneously grouped students for special instructional treatment. The middle 50 percent of the mathematics-ability distribution were assigned to the lecture treatment. The upper and lower 25 percent groups were assigned to the programmed, self-paced treatment. No formal studies to confirm the effectiveness of this practice were performed. Since then, the sectioning practice was discontinued. At the time of the study, students of all ability levels were taught by both methods. The existence of alternative treatments

with students of varying aptitudes for mathematics instruction gave rise to five research questions. These research questions were the basis for the null hypotheses.

1. Should the offering of both lecture and programmed instructional methodologies be continued?

2. Should sectioning by ability level for different instructional methods be reinstated?

3. Should a prerequisite learning experience be established for students with low mathematics ability?

4. Should attitudes toward mathematics be considered with mathematics ability in sectioning decisions?

5. Should the collection of students' opinions of the teaching methodology be implemented?

The criterion for judging Questions 1, 2, 4, and 5 was the .05 level of significance on the appropriate statistical test. The criterion for judging Question 3 was based on an institutional practice which sought at least an 80 percent chance for students to earn a "C" or better grade in an entry-level mathematics course.

Literature

These questions provided the basis for a literature review that included (1) studies that compared two or more instructional methods in high school or collegiate business mathematics; (2) studies that compared programmed, individualized, or personalized systems to the lecture method for entry-level college mathematics; (3) studies that sought to identify aptitude-treatment interactions in mathematics

instruction; (4) studies on mathematics course placement; and (5) promising variables relevant to future studies.

In 12 studies that focused on business mathematics, seven found support for the programmed approach and one found mixed results. Four studies reported no differences. The lecture method was not found to be superior in any of the studies. Quasi-experimental research designs were used in all but two of the studies.

Another group of 13 studies that dealt with introductory college-level mathematics were reviewed. The lecture method was compared to the individualized, programmed, self-paced, or other treatments (some involving the small-group discussion method). Eight of the studies used an experimental design; the remainder used quasi-experimental designs. A relationship between type of design and results was not apparent. In only one case did the lecture method prove superior. In three studies, achievement was equal and in seven studies the alternative method was favored. Thus, in the 25 studies reviewed, the lecture method produced better achievement only once. Such an outcome could be expected by chance alone. In general, the literature provided support for studies that would challenge the effectiveness of the lecture method in mathematics instruction.

The literature on aptitude-treatment interactions in mathematics education defied a neat summary. The aptitude dimension has included variables such as mathematical ability, attitudes toward mathematics, anxiety, and locus of control. Assignment of students to aptitude groups has been determined by univariate and multivariate

procedures. The treatment dimension has included arithmetic, algebra, and calculus; logical sequencing of content and scrambled sequencing of content; units within courses, full courses, and series of courses; and programmed and lecture methods. Sample size per treatment has varied from 2 to 25 to over 100. Outcome measures have included test scores, grades, problem-solving ability, attitudes, and cognitive-style measures. Mediating variables such as time-on-task have been used. Research designs were evenly divided between experimental and quasi-experimental. The complexity of ATI research noted by Cronbach and Snow (1981) was evident in this review. Snow's (1970) statement of need for a grand matrix that identifies learning environments where learners of different characteristics thrive has yet to be realized.

The course-placement literature produced evidence that remediation instruction can be effective (Rhodes, 1984) and that proper instructional sequencing and course placement lead to improved achievement (Bone, 1981; J. Smith, 1982). Also, multivariate procedures including ability and attitudes to predict course grades and influence course placement have potential for improved practices (Byrd, 1980; Decker, 1974; Helmick, 1983; Sims, 1980). Measures of cognitive styles may have potential for future studies.

Method

The study was conducted in all business mathematics classes during the winter academic term of 1983-84 at Ferris State College. One hundred twelve students comprising five classes completed the

lecture teaching methodology. One hundred twenty-three students comprising two classes completed the programmed teaching methodology. Students were assigned to one of four ability-level groups based on the ACT Mathematics test score. The quartiles were used for the blocking. Scores of 01 to 08 were assigned to the Low group, 09 to 12 to the Lower Middle group, 13 to 18 to the Upper Middle group, and 19 to 32 to the High group. The design used was the nonequivalent control group since random assignment to instructional treatment was not feasible.

Beyond the ACT Mathematics test, the pretests included the other three ACT subtest scores: English, Social Studies, and Natural Sciences. Also, the ACT self-reported high school grades were obtained. In addition, the Mathematics Attitude Inventory and the Business Mathematics Questionnaire were administered on the first day of class. The Business Mathematics Final Examination was administered as a pretest in the most representative class section so that gain scores could be estimated. The posttest measures were the Business Mathematics Final Examination and the final grade in the course. The data were analyzed by using the BMDP statistical package on the mainframe computer at Ferris State College.

Results

The first research question was concerned with the continuation of offering the two instructional methodologies. The statistical analysis consisted of t-tests for gain scores for students in each methodology. The lecture method estimated mean gain was 13.9; the programmed method estimated mean gain was 15.9. A large t-value

(p < .01) for each method was found, which led to the rejection of the hypotheses that the gain scores would be equal to zero. Both methods produced highly significant gains; consequently, both methods were considered productive and useful.

A t-test to compare the respective mean gains was performed. The observed difference of two points favored the programmed method (p < .05). The finding was similar to that of Miller (1984), Brown (1984), and Wells (1982), who studied business mathematics. However, the result should not be taken to imply that the programmed method was superior for all students. The second research question provided a more detailed investigation into the comparative worth of the two methodologies.

The second research question dealt with sectioning by ability levels for the different methodologies. Aptitude-treatment interactions, if observed, would have supported a return to a practice of sectioning by ability level. The study of interaction also clarified the finding that programmed students experienced superior gain. Analysis of variance was applied to the Business Mathematics Final Examination score. Significant F-values for the main effects and the interaction effect were found (p < .05). Consequently, Scheffe's post hoc comparison procedures were used to construct 95 percent confidence intervals around the difference between the means for each ability level. Where the confidence interval excluded zero, the null hypothesis was rejected.

For the High ability group, the programmed method was favored and the null hypothesis was rejected. This finding was similar to that of T. Smith (1983) and five studies reviewed by Cronbach and Snow (1977). For the Mid-High group, the programmed method was favored slightly but the null hypothesis was accepted. For the Mid-Low group the programmed method was favored and the null hypothesis was rejected. For the Low group the lecture method was favored slightly, but the null hypothesis was accepted. Thus, clear support for the programmed method was found for two of the four ability groups, the High and Mid-Low groups. However, closer inspection of the means revealed an inconsistency in the data.

For the programmed aptitude groups, the posttest means on the Final Business Mathematics Test were ordered from high to low, in correspondence with the aptitude groupings. The same consistency was not apparent for the lecture group. The Mid-Low group mean of 19.7 was below the Low group mean of 21.4. This within-method reversal was not anticipated or explainable. Therefore, a follow-up analysis on final grades was performed. The same pattern was observed.

Further inquiry into the pretest attitudinal measures was conducted. It was discovered that two attitudinal measures provided useful information. The interaction patterns for Motivation for Mathematics and Enjoyment of Mathematics conformed to the patterns for the posttest measures. The Low lecture group means were higher than the Mid-Low lecture group means. This finding confirmed that a preexistent interaction between method, ability, and attitude was present.

Identification of reasons for this occurrence goes beyond the scope of this study. However, the findings suggested that (1) the results of the study should not be generalized beyond the term in which the study was conducted and (2) the rejection of the null hypothesis for the Mid-Low groups might be a false rejection (Type I error). The condition observed in this study may not reoccur. However, the findings that supported the superiority of the programmed method for the High ability group should stand if a replication of this study were to be carried out.

The third research question was concerned with the need for a prerequisite course for students with low mathematics ability. The criterion was at least an 80 percent chance of earning a "C" or better final grade in Business Mathematics 121. The analysis showed that students who scored below 17 on the ACT Mathematics test, n = 148 (63 percent), would be eligible for a prerequisite course. If the criterion had been dropped to a 70 percent chance of "C" or better grades, then those who scored below 13, n = 117 (50 percent), would be eligible for a prerequisite course.

In fact, many students had taken courses that would be logical choices for a prerequisite experience. This permitted an analysis, according to institutional course-placement guidelines, to determine whether potential prerequisite courses were demonstrably effective. However, the effects of completion of a prerequisite course could not be shown. Similarly, Whitesitt (1980) found that all of the remedial mathematics courses at Montana State University were ineffective in

developing competence in most areas identified as important to success in subsequent courses. Totten (1983) found similar results at Ferris State College.

Several potential reasons for this finding were suggested and should be considered in further research. Suggestions by Totten (1983) should be considered also. It was concluded that a prerequisite learning experience for approximately 60 percent of the students was advisable, but the nature of the experience could not be ascertained.

The fourth research question dealt with the usefulness of attitudinal measures in making sectioning decision. Stepwise multiple regression controlled the entry of variables so that the contribution of the ability measures in predicting final grades could be exhausted before the attitudinal measures were entered. In the fifth step, the Self-Concept in Mathematics measure was entered. The F-to-enter was 16.1457, significant at the .01 level, and the increase in multiple R was over 4 percent. Consequently, the use of attitudinal measures in a sectioning procedure should be considered. A prediction equation was developed for this purpose.

Since analysis of aptitude-treatment interactions suggested that preexisting attitudes toward mathematics influenced achievement for the lower-half ability group, follow-up analysis was performed. For the lecture method, the best predictor was Enjoyment of Mathematics and, overall, attitudes accounted for 14 percent, or almost one-half, of the explainable variance. For the programmed method, the contribution of attitudinal measures was negligible. The result suggested that

special attention to attitudes be given the lower half of the ability distribution in the lecture courses.

The fifth research question was concerned with the use of student opinions about the teaching methodology. A multivariate test, Hotelling's T^2, was used to analyze the results of a seven-item questionnaire. The multivariate F-value was not significant, which suggested that student opinions about the methodology were not highly contributory to the other outcomes. However, the data suggested that high-ability students in the programmed method felt better about the method's contribution to use of out-of-class time than their counterparts in the lecture methodology.

Recommendations

Students gained considerable knowledge about business mathematics under each method of instruction, but the former sectioning practice of placing the high and low quartiles in the programmed classes and the middle quartiles in the lecture classes received only partial support. The programmed method was favored for three subgroups (High, Mid-High, and Mid-Low). The differences in performance for the High and Mid-Low groups were statistically significant.

1. Consideration should be given to making greater use of the programmed method. Replication of the study in other terms would provide greater confidence that the programmed instruction is the method of choice for higher aptitude groups.

2. Especially needed is further study of the lower half of the aptitude distribution, where unexpected differences in attitude were

5. Although differential student preferences for course methodology were not found, such data should be a part of future studies.

6. Multivariate approaches to sectioning and placement decisions should be studied. The power of discriminant analysis to classify successfully placed students should be a part of any multivariate studies carried out.

7. Other variables that may help explain achievement, such as cognitive style, should be considered for future studies.

APPENDICES

APPENDIX A

BUSINESS MATHEMATICS QUESTIONNAIRE

Business Mathematics Questionnaire

The purpose of this survey is to help the researcher learn about the mathematics background of Business Math 121 students. Please answer each question.

Name: ________________________ Soc.Sec.# ________________

1. What is your current status? (check one)
   _____ 1. Freshman
   _____ 2. Sophomore
   _____ 3. Junior
   _____ 4. Senior

2. When did you graduate from high school? (check one)
   _____ 1. 1983
   _____ 2. 1982
   _____ 3. 1981
   _____ 4. 1980
   _____ 5. 1979 or before

3. How many semesters of high school math courses did you have? (check one)
   _____ 1. zero
   _____ 2. one or two
   _____ 3. three or four
   _____ 4. five or six
   _____ 5. seven or more

4. How many previous college math courses have you taken? (check one)
   _____ 1. zero
   _____ 2. one
   _____ 3. two
   _____ 4. three
   _____ 5. four or more

5. If you checked other than "zero" in #4, please indicate which courses you took. (check as many as apply)
   _____ 1. Math 090 or equivalent
   _____ 2. Math 111 or equivalent
   _____ 3. Math 121 or equivalent
   _____ 4. Course above college algebra

6. Sex
   _____ 1. Male
   _____ 2. Female

7. Major Field of Study:
   ____

APPENDIX B

BUSINESS MATHEMATICS 121

COMPREHENSIVE FINAL EXAMINATION

BUSINESS MATHEMATICS 121

COMPREHENSIVE FINAL EXAMINATION

DIRECTIONS: Use a No. 2 pencil to mark answers on the machine scoreable answer sheet. Make good clean erasures if changing an answer. Do your scratch work on the test itself. A calculator may be used.

1. 144 is 36% of what number?
   a. 51.84
   b. 5184.00
   c. 195.84
   d. 400.00

2. What percent of 350 is 28?
   a. 8%
   b. 12.5%
   c. 98%
   d. 93%

3. What is 20% of $8,000?
   a. $160.00
   b. $400.00
   c. $4000.00
   d. $1600 00

4 - 5 Balance shown on the bank statement of the Murphy Chemical Co., June 30, 19-- was $3,650.55. Balance shown by the checkbook, $3874.12. Checks outstanding: No. 336 - $38.50, No. 387 - $28.43, No. 395 -$6.25, No. 396 - $115, No. 397 - $80.75. Charge for imprinting checks - $9.00. Service charges - $3.50. Deposit in transit, $480.00

4. What is the Bank Balance?
   a. $4130.55
   b. $3861.62
   c. $3381.62
   d. $4188.05

5. What is the Checkbook Balance?
   a. $4188.05
   b. $4130.55
   c. $3861.62
   d. $3381.62

6 - 9 The following list itemizes the anticipated expenses of a county government for the coming year. Property in the county is assessed at $62,450,000.

Education, $3,600,000
Police and fire protection, $2,100,000
Roads, $759,000
Parks, $220,000
Retirement of Debt, $190,500

6. What is the county's budget for next year?
   a. $619,500.00
   b. $69,309,500.00
   c. $6,869,500.00
   d. $6,186,400.88

7. What is the tax rate, expressed as a percent?
   a. 11%
   b. .011%
   c. 9%
   d. 9.1%

8. What is the tax on $1.00?
   a. $.09
   b. $.011
   c. $.11
   d. $.091

9. What are the annual taxes for a piece of property assessed at $42,000.00?
   a. $1486.90
   b. $163.56
   c. $1486.00
   d. $4620.00

10. Find the principal (P) when the rate (R) is 10%, the time (T) is 180 days and the interest (I) is $100.00.
    a. $2000.00
    b. $5000.00
    c. $5.55
    d. $1666.67

11. Find the time (T) when the principal is $15,000.00, the rate (R) is 12%, and the interest is $900.00.
    a. 139 days
    b. 144 days
    c. 180 days
    d. 72 days

12. Find the rate (R) when the principal (P) is $4,000.00, the time (T) is 144 days and the interest (I) is $120.00.
    a. 75%
    b. 7.5%
    c. .075%
    d. 3/4%

13. Find the interest (I) when principal (P) is $560.00, the rate (R) is 8 1/2%, and the time (T) is 3 months.
    a. $264.00
    b. $47.85
    c. $142.80
    d. $11.90

14 - 17 Discount Problems I and II.

	Face Value	Time	Date	Discount Date	Interest Rate	Discount Rate	Maturity Value	Proceeds
I.	$400	90 days	June 16	July 18	8%	9%	?	?
II.	$200	120 days	May 11	June 10	9%	10%	?	?

14. For problem I, what is the Maturity Value?
    a. $432.00
    b. $409.00
    c. $408.00
    d. $405.42

15. For problem I, what are the Proceeds?
    a. $402.08
    b. $393.12
    c. $402.06
    d. $425.52

16. For problem II, what is the Maturity Value?
    a. $218.00
    b. $206.00
    c. $204.65
    d. $206.15

17. For problem II, what are the Proceeds?
    a. $199.13
    b. $196.20
    c. $204.28
    d. $200.85

18. The retail price of an automobile is $8100. Purchased on a credit plan of 36 monthly installments, the price jumps to $10,100. Calculate the true annual percentage rate (effective rate of interest) using the formula:

Programmed Classes: $APR = \frac{24F}{D\ (T + 1)}$

Regular Classes: $R = \frac{2MI}{P\ (n + 1)}$

a. 16%
b. 12.8%
c. 52%
d. 15.2%

19 - 20 What is the markon and selling price of an article costing $235 and has a markon of 40% of the cost?

19. What is the Markon?
a. $94.00
b. $156.66
c. $352.50
d. $141.00

20. What is the Selling Price?
a. $391.66
b. $587.50
c. $329.00
d. $141.00

21 - 22 Find the selling price and markon for an article costing $55 and has a markon of 25% of the selling price.

21. What is the Selling Price?
a. $73.33
b. $128.33
c. $220.00
d. $68.75

22. What is the Markon?
a. $13.75
b. $165.00
c. $73.33
d. $18.33

23 - 26 For problems I and II, find the invoice price and cash price of the following invoices. Assume that they are paid within the discount period.

	List Price	Trade Discounts	Invoice Price	Terms	Value of Returned Goods	Amount of Payment
I.	$3,000	33 1/3%, 25%, 15%	?	3/10, n/60	$50	?
II.	$ 865	33 1/3%, 40%, 10%	?	2/10, n/30	$12	?

23. For problem I, what is the Invoice Price?
    a. $1725.00
    b. $1275.00
    c. $1062.50
    d. $1253.75

24. For problem I, what is the Amount of Payment?
    a. $1216.14
    b. $1188.25
    c. $1624.75
    d. $1030.62

25. For problem II, what is the Invoice Price?
    a. $553.60
    b. $307.08
    c. $311.40
    d. $417.48

26. For problem II, what is the Amount of Payment?
    a. $300.94
    b. $293.17
    c. $530.77
    d. $293.41

27 - 30 Overtime is paid for over 40 hours worked per week. The overtime rate is 1 1/2 times the regular rate. (Use the FICA rate as 6.13%.)

	Person	Total Hours	Hourly Rate	Gross Pay	FICA (at 6.13%)
I.	Fletcher	46	$3.90	?	?
II.	Enyart	45 1/2	$4.00	?	?

27. For problem I, what is the Gross Pay?
    a. $179.40
    b. $191.10
    c. $214.50
    d. $167.70

28. For problem I, what is the FICA?
    a. $11.18
    b. $11.00
    c. $11.52
    d. $11.71

29. For problem II, what is the Gross Pay?
    a. $171.00
    b. $204.00
    c. $193.00
    d. $182.00

30. For problem II, what is the FICA?
    a. $11.29
    b. $11.83
    c. $11.16
    d. $11.47

31 - 33 Depreciation Problems. Using the Straight Line Method, cost of equipment = $8800, scrap value = $600, and estimated life = 8 years.

31. What is the amount of depreciation for the first year?
    a. $1025.00
    b. $8200.00
    c. $1035.00
    d. $2050.00

32. What is the Book Value at the end of the first year?
    a. $6775.00
    b. $7175.00
    c. $8200.00
    d. $7775.00

33. What would be the amount of depreciation if this equipment was purchased on October 4.
    a. $2050.00
    b. $1025.00
    c. $854.17
    d. $256.25

APPENDIX C

COURSE OUTLINE--LECTURE

FERRIS STATE COLLEGE
BIG RAPIDS, MICHIGAN

TO: Winter Quarter Business Math Teachers

FROM: Malcolm E. Lund, Head, Office Administration

SUBJECT: Business Math Classes

DATE: November 9, 1983

After our meeting the other day, a check was made to determine material that should be included. The following chapters are the ones in the Rice book which should be included:

Section	Coverage
3	Bank Records
5,6	Fractions
10	Percentages
11	Cash and Trade Discounts
13	Markup
14	Simple Interest
15	Notes and Interest Variables
16	Borrowing by Business
17	Charges for Credit
18	Payroll Records
19	Payroll Deductions
20	Property Tax
25	Depreciation

Optional:

7,8	Decimals
12	Commission
32	Compound Interest and Present Value

MEL:smd

APPENDIX D

COURSE OUTLINE--PROGRAMMED

B-121: Business Mathematics

TEXT: Huffman, <u>Programmed Business Mathematics</u>, Book 1 and Book 2, Fourth Edition, Gregg Division, McGraw-Hill Book Co.

BOOK I

UNIT	PAGES	TOPICS	CHECKPOINTS
1,2	OMIT		
3	23 - 30	Addition and Subtraction of Fractions	31
4	33 - 38	Multiplication and Division of Fractions	39
5	41 - 50	The Use of Decimals	51
6	OMIT		
7	63 - 66	Introduction to Percent	67
		TEST 1 (UNITS 3, 4, 5, 7)	
8	74 - 80	The Use of Business Formulas	81
9	OMIT		
10	93 - 98	The Percentage Formula	99
11	101 - 106	Percentage Problems in Business	107
12	114 - 122	Bank Reconciliation	123
13	OMIT		
14	131 - 138	Property Taxes	139
15	141 - 150	Computation of Commission	151
16	153 - 158	Money Management	159
		TEST 2 (UNITS 8, 10-12, 14-16)	

BOOK II

UNIT	PAGES	TOPICS	CHECKPOINTS
1	2 - 8	Computing Interest	9
2	11 - 18	Using Interest Tables	19
3	21 - 30	Negotiable Instruments	31
4	33 - 38	Introduction to Discount	39
5	41 - 46	Discounting Noninterest-Bearing Notes	47
6	49 - 54	Discounting Interest-Bearing Notes	55
7	57 - 62	Consumer Credit	63
		TEST 3 (UNITS 1-7)	
8	70 - 76	Pricing Policy	77
9	79 - 86	Markon on Selling Price and Markon on Cost	87
10	89 - 94	Computing Cash Discount	95
11	97 - 104	Special Problems in Computing Cash Discount	105
12	107 - 114	Computing Trade Discount	115
		TEST 4 (UNITS 8-12)	
13	122 - 132	Payroll Procedures	133
14	135 - 144	Determining Gross Pay	145
15	147 - 158	Determining Net Pay	159
16	Depreciation - No Text - See Instructor for Handout		
		TEST 5 (UNITS 13-15 plus Depreciation)	
		TEST 6 - Comprehensive Examination	

APPENDIX E

BUSINESS MATHEMATICS--METHODOLOGY EVALUATION

Business Mathematics

Methodology Evaluation

Different methods can be used to teach Business Mathematics. Some of the methods are (a) the traditional lecture method, (b) the programmed, self-paced method, (c) the independent, non-classroom method, (d) the television method, etc. This questionnaire asks your opinion about the method used in this class. It is not an evaluation of your instructor.

Your opinions are provided for research on instructional methods in Business Mathematics. Your name is provided solely for research purposes. The data will not be used to affect your instructor's perception of you or to evaluate your instructor.

NAME:______________________ Soc.Sec.No:____________________

Question A asks which method you experienced. Questions 1-7 ask your opinion of the method's meaning to you.

If you Strongly Agree with the statement, circle 4.
If you merely Agree with the statement, circle 3.
If you merely Disagree with the statement, circle 2.
If you Strongly Disagree with the statement, circle 1.

A. The main teaching method used in this course was the:
_____ (1) Lecture, discussion method.
_____ (2) Programmed, self-paced method.

1.	I am gaining a good understanding of concepts and principles of Business Mathematics.	1	2	3	4
2.	I am developing skills needed by professionals in business.	1	2	3	4
3.	I like the method used to present material in this course.	1	2	3	4
4.	I adjusted easily to the method of presenting material in this course.	1	2	3	4
5.	My in-class time is well-spent in this course.	1	2	3	4
6.	The method used in-class helps me make good use of my out-of-class time.	1	2	3	4
7.	I would recommend Business Mathematics taught by this method to my friends.	1	2	3	4

BIBLIOGRAPHY

BIBLIOGRAPHY

Adams, J. L. (1981). A study of achievement and attitude toward mathematics in remedial algebra (Doctoral dissertation, University of Nebraska-Lincoln, 1980). Dissertation Abstracts International, 41, 2980A.

Adams, R. C. (1981). A study of the effects of PSI and lecture teaching methods upon student achievement and attitude change in college mathematics (Doctoral dissertation, Northern Arizona University, 1981). Dissertation Abstracts International, 42, 519A.

American College Testing. (1973). Technical report of the ACT assessment program. Iowa City: American College Testing.

American College Testing. (1984). Content of the test in the ACT assessment. Iowa City: American College Testing.

Artz, A. F. (1984). The comparative effects of the student-team method of instruction and the traditional teacher-centered method of instruction upon student achievement, attitude, and social interaction in high school mathematics courses (Doctoral dissertation, New York University, 1983). Dissertation Abstracts International, 44, 3619A.

ASCD Committee on Research and Theory. (1980). Measuring and attaining the goals of education. Alexandria, VA: Association for Supervision and Curriculum Development.

Barger, P. A. (1975). The relationship of the general aptitude test battery and other factors to the successful completion of business mathematics in selected vocational-technical schools in Georgia (Doctoral dissertation, Georgia State University, 1975). Dissertation Abstracts International, 36, 669A.

Bennett, E. C. (1983). The relationship between selected demographic, academic, and aptitude variables and student grade achievement in a first course on computer science (Doctoral dissertation, Mississippi State University, 1982). Dissertation Abstracts International, 43, 2168A.

Berston, H. M., & Fisher, P. (1978). Collegiate business mathematics (Rev. ed.). Homewood, IL: Richard D. Irwin, Inc.

Bohnhorst, B. (1982, November 1). Lecture presented to EAC 810C, Curriculum construction course at Michigan State University, East Lansing.

Bone, M. A. (1981). A comparison of three methods of mathematics placement for college freshmen (Doctoral dissertation, Michigan State University, 1981). Dissertation Abstracts International, 42, 565A.

Bouknight, M. L. (1984). The effects of instructional method on types of learning outcomes as evidenced by differential performance (Doctoral dissertation, North Carolina State University at Raleigh, 1983). Dissertation Abstracts International, 44, 3002A.

Brinkerhoff, R. O., Brethower, D. J., Hluchyj, T., & Nowakowski, J. R. (1983). Program evaluation: A practitioner's guide for trainers and educators. Boston: Kluwer-Nijhoff Publishing.

Brown, V. L. (1984). An analysis of an individual study instructional approach of teaching mathematical concepts to high school vocational office education students (Doctoral dissertation, North Texas State, 1983). Dissertation Abstracts International, 44, 2333A.

Byrd, D. L. (1980). A study to determine the significance of certain high school and college data in predicting students' success in college algebra, pre-college algebra, and basic general mathematics at Enterprise State Junior College (Doctoral dissertation, Auburn University, 1979). Dissertation Abstracts International, 40, 5346A.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. Chicago: Rand McNally & Co.

Carstens, J. C. (1973). Relationship between business career objectives and the supporting course business mathematics (Doctoral dissertation, Colorado State University, 1971). Dissertation Abstracts International, 32, 4499A.

Center for Research on Learning and Teaching. (1976, October). Student reactions to instruction. Memo to the Faculty No. 58. Ann Arbor: The University of Michigan.

Clithero, D. L. (1984). A comparison and evaluation of two instructional programs for the teaching of probability and statistics to eighth grade students (Doctoral dissertation, University of Missouri-Columbia, 1983). Dissertation Abstracts International, 44, 3620A.

Cope, C. L., Jr. (1980). A comparison of a large lecture format featuring small group discussion with a traditional lecture test format in a decision mathematics course (Doctoral dissertation, Georgia State University, 1980). _Dissertation Abstracts International_, _41_, 973A.

Cronbach, L. J. (1967). How can instruction be adapted to individual differences? In R. M. Gagen (Ed.), _Learning and individual differences_. Columbus, OH: Merrill Books.

Cronbach, L. J., & Snow, R. E. (1977). _Aptitudes and instruction methods_. New York: Irvington Publishers, Inc.

Cronbach, L. J., & Snow, R. E. (1981). _Aptitudes and instruction methods_ (2nd ed.). New York: Irvington Publishers, Inc.

Cullen, M. A. (1980). An investigation into the cognitive styles of community college students and the effects of instructional treatment of their mathematics achievement (Doctoral dissertation, University of Massachusetts, 1980). _Dissertation Abstracts International_, _41_, 144A.

Decker, D. F. (1974). _Applicability of ACT scores to the prediction of success in business, mathematics and science courses at Rhode Island Junior College_. Practicum submitted to Nova University in partial fulfillment of requirements for Doctor of Education degree. (ERIC Documents, ED 097 946)

Delventhal, E. F. (1982). The effects of the use of a mathematics tutoring center on the achievement and attitude of intermediate algebra students at the college level (Doctoral dissertation, The University of Connecticut, 1982). _Dissertation Abstracts International_, _43_, 1456A.

Eldersveld, P. J. (1981). The relationship of field dependence-independence, student perceptions, and mathematics preparation to success and failure in developmental mathematics at selected community colleges in northern Illinois (Doctoral dissertation, Northern Illinois University, 1981). _Dissertation Abstracts International_, _42_, 517A.

Evans, R. N., & Herr, E. L. (1978). _Foundations of vocational education_. Columbus, OH: Merrill Publishing Co.

Ferguson, G. A. (1966). _Statistical analysis in psychology and education_ (2nd ed.). New York: McGraw-Hill Book Co.

Gagne, R. M. (1967). Instruction and conditions of learning. In S. L. Siegel (Ed.), _Some contemporary viewpoints_. San Francisco: Chandler Publishing Co.

Glass, G. V., & Stanley, J. C. (1970). Statistical methods in education and psychology. Englewood Cliffs, NJ: Prentice-Hall.

Godia, G. I. (1982). A comparative study of the effects of achievement, changes in attitude toward mathematics and attrition rate of students enrolled in a freshman remedial arithmetic course under two different instructional approaches (Doctoral dissertation, Ohio University, 1981). Dissertation Abstracts International, 42, 3412A.

Hall, A. L. (1972). Business mathematics achievement and career objectives at the community college level (Doctoral dissertation, Colorado State University, 1972). Dissertation Abstracts International, 33, 2565A.

Hall, G. (1974, January 8). A comparative study of specific skill requirements of selected employees and clerical course content in a community college district. Practicum submitted to Nova University in partial fulfillment of the requirements for Doctor of Education. (ERIC document, ED 097 090)

Harkins, R. J. (1980). The effect of mode of presentation on attitudes toward and achievement in mathematics (Doctoral dissertation, Indiana University, 1980). Dissertation Abstracts International, 41, 3930A.

Harsher, S. L. (1983). An investigation of the affective and cognitive effects of the teacher-directed conventional method, the student-directed individualized method, and the student-directed competency based method of instruction in secondary business mathematics classes (Doctoral dissertation, University of Maryland, 1982). Dissertation Abstracts International, 43, 2208A.

Helmick, F. I. (1983). Evaluation of the placement test for first-year mathematics at the University of Akron (Doctoral dissertation, The University of Akron, 1983). Dissertation Abstracts International, 44, 401A.

Hickey, P. S. (1980). A long range test of aptitude treatment interaction hypothesis in college mathematics (Doctoral dissertation, The University of Texas at Austin, 1980). Dissertation Abstracts International, 41, 145A.

Higab, A. K. A. (1983). The effects of aptitudes and structurally different methods of teaching mathematics on achievement and satisfaction (Doctoral dissertation, University of Southern California, 1983). Dissertation Abstracts International, 43, 3787A.

Hinton, J. R. (1980). An analysis of selected cognitive style dimensions related to mathematics achievement, aptitude, and attitudes of two-year college students (Doctoral dissertation, Ohio State University, 1980). Dissertation Abstracts International, 41, 576A.

Huffman, H. (1980). Programmed business mathematics (3 vols.). New York: McGraw-Hill Book Co.

Iverson, G., & Norpath, H. (1976). Analysis of variance. Series: Quantitative applications in the social sciences, 07-01. Beverly Hills & London: Sage Publications.

Johnson, R. S. (1974). The business mathematics competencies needed by career business students in two-year colleges (Doctoral dissertation, State University of New York at Albany, 1973). Dissertation Abstracts International, 34, 4507A.

Jorgenson, P. R. (1981). A survey of remedial/developmental mathematics programs at two-year public colleges (Doctoral dissertation, Wayne State University, 1981). Dissertation Abstracts International, 42, 973A.

Kaliski, B. S. (1975). Algebra or arithmetic? Journal of Business Education, 50, 289-90.

Kaufman, S. (1980). The comparison between the utilization of behavioral objectives in the teaching of mathematics of merchandising in the distributive education curriculum and traditional teaching (Doctoral dissertation, Temple University, 1980). Dissertation Abstracts International, 42, 676A.

Khan, A. A. (1983). A comparison of conventional lecture method of instruction with programmed instruction and the lecture-laboratory approach in teaching introductory physical geography at the university level (Doctoral dissertation, The Catholic University of America, 1983). Dissertation Abstracts International, 44, 454A.

Koran, M. (1974). Aptitude, achievement, and the study of aptitude-treatment interaction. In D. R. Green (Ed.), The aptitude-achievement distinction. Monterey: CTB/McGraw-Hill.

Liguori, R. A. (1974). A controlled study of P.S.I. procedures applied to a college business mathematics course (Doctoral dissertation, The University of New Mexico, 1973). Dissertation Abstracts International, 35, 1551A.

Mackenzie, D. (1975). Large group lecturing in mathematics. Educational Studies in Mathematics, 6, 293-309.

McComb, J. A. (1984). Mathematics placement procedures and psychometric decision theory (Doctoral dissertation, Michigan State University, 1983). Dissertation Abstracts International, 44, 2742A.

McLeod, D., & Adams, V. M. (1980). Aptitude-treatment interaction in mathematics instruction using expository and discovery method. Journal for Research in Mathematics Education, 11, 225-234.

Miller, K. N. (1984). The effect of the individualized manpower training systems instruction program in basic math skills on the achievement level and dropout and failure rate of mathematics of business students at Daytona Beach Community College (Doctoral dissertation, Florida Atlantic University, 1983). Dissertation Abstracts International, 44, 3254A.

Muzik, S. T. (1984). A single-subject experimental study of time on task for selected classroom aptitude, treatment and achievement interaction variables (Doctoral dissertation, Washington State University, 1983). Dissertation Abstracts International, 44, 3271A.

Newman, J. S. (1983). A comparison of traditional classroom, computer, and programmed instruction (Doctoral dissertation, University of South Carolina, 1983). Dissertation Abstracts International, 44, 976A.

Oravetz, R. F. (1967). A study of the effectiveness of different experimental drill patterns in business mathematics (Doctoral dissertation, University of Pittsburgh, 1966). Dissertation Abstracts International, 27, 3373A.

Payne, H. E. (1984). The effects of three instructional techniques on the problem solving ability of general education mathematics students at the junior college level (Doctoral dissertation, University of South Florida, 1983). Dissertation Abstracts International, 44, 2670A.

Peterson, P. L. (1982). Individual differences. In Encyclopedia of educational research (Vol. 2). New York: Macmillan.

Reinauer, C. D. (1981). An investigation of selected intellective and nonintellective variables and their use in predicting success in two instructional formats of a college algebra course (Doctoral dissertation, University of Houston, 1979). Dissertation Abstracts International, 41, 3932A.

Rhodes, T. M. (1984). A study to assess and compare the effects and attitude of two remediation efforts in mathematics by the Ohio State University (Doctoral dissertation, The Ohio State University, 1983). Dissertation Abstracts International, 44, 3312A.

Rice, L. A., Mayne, F. B., Deity, J. E., & Southam, J. L. (1983). Business mathematics for colleges (8th ed.). Cincinnati: Southwestern Publishing Co.

Robertson, D. F. (1980). An investigation of aptitude treatment interactions (ATI) with respect to programmed and lecture treatments in a college course in basic mathematics (Doctoral dissertation, University of Minnesota, 1979. Dissertation Abstracts International, 40, 4940A.

Sandman, R. S. (1973). The development, validation, and application of a multidimensional mathematics attitude instrument. Unpublished doctoral dissertation, University of Minnesota.

Sandman, R. S. (1980). The mathematics attitude inventory: Instrument and user's manual. Journal for Research in Mathematics Education, 11, 148-149.

Schalock, H. D. (1976). Structuring process to improve student outcomes. In O. T. Lenning (Ed.), Improving educational outcomes. San Francisco: Jossey-Bass.

Schielack, V. P. (1983). A personalized system of instruction versus a conventional method in a mathematics course for elementary education majors (Doctoral dissertation, The University of Texas at Austin, 1982). Dissertation Abstracts International, 43, 2267A.

Schwartz, H. I. (1980). A mastery learning study in remedial mathematics in an urban community college (Doctoral dissertation, Columbia University, 1980). Dissertation Abstracts International, 41, 577A.

Scrittorale, L. (1973). The business mathematics needs of community/junior college business majors (Doctoral dissertation, Colorado State University, 1972). Dissertation Abstracts International, 33, 6656A.

Shine, S. S. (1983). A comparison of programmed instruction versus lecture-demonstration as a method for teaching digital computer arithmetic at the post-secondary school level (Doctoral dissertation, Texas A & M University, 1982). Dissertation Abstracts International, 43, 3529A.

Sims, G. L. (1980). Prediction of success in college algebra at Richland College in Dallas, Texas (Doctoral dissertation, The Florida State University, 1979). Dissertation Abstracts International, 40, 5351A.

Smith, J. L. (1982). A study of the relationships of sequences of enrollment in college remedial mathematics to grades in a subsequent college algebra course and to persistence in college (Doctoral dissertation, The University of Alabama, 1982). Dissertation Abstracts International, 43, 1457A.

Smith, T. H. (1983). The effects of a self-paced college algebra program on mathematics achievement and mathematics anxiety (Doctoral dissertation, Temple University, 1983). Dissertation Abstracts International, 44, 96A.

Snow, R. E. (1970). Research on media and aptitudes. Commentaries on research in instructional media: An examination of conceptual schemes viewpoints. In G. Salomon & R. E. Snow (Eds.), Bulletin of the Indiana University School of Education, 46, 63-91.

Swartz, F. (1982a, May). A study of internal validity and reliability of the mathematics attitude inventory for business mathematics students. Unpublished paper presented in Education 822F at Michigan State University, East Lansing.

Swartz, F. (1982b, August). Development of a business mathematics final examination. Unpublished paper presented in Education 984, Field Experience in Vocational Education, Michigan State University, East Lansing.

Swartz, F. (1983). Business mathematics in Michigan community and two-year colleges. MBEA Today, 48, 4-5.

Swartz, F., & Swartz, R. A. (1981). College business mathematics: Pretesting for course sectioning. Business Education Form, 8-9.

Tabachnick, B. G., & Fidell, L. S. (1983). Using multivariate statistics. New York: Harper & Row Publishers.

Tobias, S. (1981). Adaptations to individual differences. In F. H. Farley & N. J. Gordon (Eds.), Psychology and education: The state of the union. Berkeley: McCutchan.

Totten, J. (1983, November). Will placement in small homogeneous lecture-discussion classes in fundamentals of college algebra help low-achieving students maintain their grades in future mathematics courses? Unpublished paper submitted in EAC 883, Readings and Independent Study in Administration and Curriculum, Michigan State University, East Lansing.

Truckson, E. B. (1983). The effects of heuristic teaching and instruction in problem-solving on the problem-solving performance, mathematics achievement, and attitudes of junior college arithmetic students (Doctoral dissertation, University of Cincinnati, 1982). Dissertation Abstracts International, 43, 3532A.

Urbatsch, T. D. (1980). An interaction study: Locus of control, mathematical attitude, mathematical anxiety, and mathematical achievement with three modes of instruction--personalized system of instruction, traditional lecture and five day lecture (Doctoral dissertation, The University of Iowa, 1979). Dissertation Abstracts International, 40, 6180A.

Walker, B. W. (1981). An experiment to determine the effects of mathematical achievement and attitude toward mathematics of prospective female elementary school teachers by the use of supplementary programmed instruction (Doctoral dissertation, Memphis State University, 1981). Dissertation Abstracts International, 42, 2478A.

Watson, J. M. (1983). Individualized mathematics instruction in an Australian university (Doctoral dissertation, Kansas State University, 1982). Dissertation Abstracts International, 43, 2268A.

Weiner, N. C. (1984). Cognitive aptitudes, personality variables and gender difference effects on mathematical achievement for mathematically gifted students (Doctoral dissertation, Arizona State University, 1983). Dissertation Abstracts International, 44, 3621A.

Weissglass, J. (1976). Small groups: An alternative to the lecture method. Two-year College Mathematics Journal, 7, 15-20.

Wells, P. L. (1982). A comparison of the achievement of university students taught by an individualized instructional approach versus the traditional instructional approach in a combined business math/business machines course (Doctoral dissertation, University of Houston, 1981). Dissertation Abstracts International, 42, 4697A.

Whitesitt, J. D. (1980). Entrance level competencies needed for beginning mathematics courses at Montana State University (Doctoral dissertation, Montana State University, 1980). Dissertation Abstracts International, 41, 1455A.

Williams, J. W. (1976). Mastery learning in business mathematics (Doctoral dissertation, The University of Nebraska-Lincoln, 1975). Dissertation Abstracts International, 36, 4978A.

Wilson, B. U. (1982). The effects of pacing and cognitive style upon student achievement and attitude in basic college mathematics (Doctoral dissertation, The College of William and Mary, 1984). Dissertation Abstracts International, 42, 4331A.

Witkowski, J. C. (1982). Cognitive-oriented supplementary material and students' cognitive process and performance in college remedial algebra (Doctoral dissertation, Illinois State University, 1982). Dissertation Abstracts International, 43, 1458A.

Woods, J. D. (1983). Lecturing: Linking purpose and organization. Improving College and University Teaching, 31, 61-64.