The Use of Programmed Texts for Remedial Mathematics Instruction in College

Charles C. White

Follow this and additional works at: https://digitalcommons.usu.edu/etd

Part of the Education Commons

Recommended Citation
https://digitalcommons.usu.edu/etd/2906
THE USE OF PROGARMED TEXTS FOR REMEDIAL MATHEMATICS
INSTRUCTION IN COLLEGE
by
Charles C. White

A dissertation submitted in partial fulfillment
of the requirements for the degree
of
DOCTOR OF EDUCATION
in
Secondary Education

UTAH STATE UNIVERSITY
Logan, Utah
1969
ACKNOWLEDGMENTS

In the fall of 1964, the Utah State University Department of Mathematics, under the direction of Dr. Neville Hunsaker, supported the recommendations of the U.S.U. Faculty Senate to make available remedial mathematics courses for those entering freshmen who had indicated deficiencies in basic high school mathematics. I would like to thank Dr. Hunsaker for giving me permission to use the subjects in the remedial mathematics courses for this investigation.

I would also like to thank Dr. Walter Borg, my first committee chairman, for helping in the initial phases of the study. However, I wish to express most of my appreciation to Dr. James Shaver, who assumed the responsibility as chairman of my committee when Dr. Borg left U.S.U. for another assignment. I sincerely appreciate the constructive criticisms Dr. Shaver expressed with regards to my dissertation. His knowledgeable suggestions were most helpful and I feel very fortunate to have had his guidance throughout the writing of this dissertation.

Finally, I wish to thank my wife, Colleen, for her typing and for her patience and encouragement which were instrumental in enabling me to fulfill this assignment.

Charles Colven White
# TABLE OF CONTENTS

ACKNOWLEDGMENTS .............................................. ii
LIST OF TABLES .................................................. vii
ABSTRACT ......................................................... x

Chapter

I. DISCUSSION OF THE PROBLEM ................................ 1
   The Basic Problem ........................................... 1
   The Problem as it Existed at Utah State University .... 4
   Subsequent Problems ....................................... 6
   Progamed learning and mental ability .................. 6
   Progamed learning and study skills .................. 8
   Progamed learning and attitudes .................. 8
   Summary of the Problems ................................ 9

II. RELATED STUDIES ............................................ 12
   Introduction .............................................. 12
   Comparison Studies ..................................... 12
   Mental Ability Studies .................................. 19
   Study Skills Studies .................................... 24
   Attitude Studies ........................................ 26
   Summary of Related Studies ............................ 30

III. OBJECTIVES AND HYPOTHESES .............................. 34
   Achievement and Variability ........................... 34
   Mental Ability ........................................... 35
   Study Skills .............................................. 39
   Interest and Attitudes .................................. 42
   Subject's Reaction to Progamed Learning ........... 43
# TABLE OF CONTENTS (Continued)

<table>
<thead>
<tr>
<th>IV. PROCEDURE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection and Characteristics of the Sample</td>
<td>45</td>
</tr>
<tr>
<td>Materials</td>
<td>52</td>
</tr>
<tr>
<td>The programed textbooks</td>
<td>52</td>
</tr>
<tr>
<td>The conventional textbook</td>
<td>53</td>
</tr>
<tr>
<td>Measures</td>
<td>53</td>
</tr>
<tr>
<td>The mathematics achievement test</td>
<td>53</td>
</tr>
<tr>
<td>The mental ability test</td>
<td>55</td>
</tr>
<tr>
<td>The study skills survey</td>
<td>56</td>
</tr>
<tr>
<td>The questionnaire</td>
<td>57</td>
</tr>
<tr>
<td>Test and Texts Comparison</td>
<td>58</td>
</tr>
<tr>
<td>Class Procedures</td>
<td>60</td>
</tr>
<tr>
<td>The experimental class</td>
<td>60</td>
</tr>
<tr>
<td>The control class</td>
<td>62</td>
</tr>
<tr>
<td>Analysis</td>
<td>62</td>
</tr>
<tr>
<td>V. FINDINGS</td>
<td>65</td>
</tr>
<tr>
<td>Preliminary Findings Pertaining to Subjects and Treatments</td>
<td>65</td>
</tr>
<tr>
<td>Subjects whose scores are reported in the analysis</td>
<td>65</td>
</tr>
<tr>
<td>Class periods used by subjects</td>
<td>66</td>
</tr>
<tr>
<td>Study outside of class</td>
<td>67</td>
</tr>
<tr>
<td>Degree of difficulty of text material</td>
<td>69</td>
</tr>
<tr>
<td>Initial Differences Between the Groups on the Covariate Measures</td>
<td>71</td>
</tr>
<tr>
<td>Mental ability</td>
<td>71</td>
</tr>
<tr>
<td>Study skills</td>
<td>72</td>
</tr>
<tr>
<td>Mathematics pretest</td>
<td>74</td>
</tr>
<tr>
<td>Summary of Initial Differences</td>
<td>76</td>
</tr>
<tr>
<td>Mathematics Posttest Scores (Unadjusted)</td>
<td>78</td>
</tr>
<tr>
<td>Relation Among the Covariates and the Mathematics Posttest Scores</td>
<td>82</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Mental ability and posttest mathematics scores</td>
<td>82</td>
</tr>
<tr>
<td>Study skills and posttest mathematics scores</td>
<td>84</td>
</tr>
<tr>
<td>Pretest and posttest mathematics scores</td>
<td>85</td>
</tr>
<tr>
<td>Mental ability and pretest mathematics scores</td>
<td>85</td>
</tr>
<tr>
<td>Mathematics Posttest Scores (Adjusted)</td>
<td>86</td>
</tr>
<tr>
<td>Mathematics Scores: Effect of Mental Ability</td>
<td>90</td>
</tr>
<tr>
<td>Fundamentals</td>
<td>91</td>
</tr>
<tr>
<td>Reasoning</td>
<td>95</td>
</tr>
<tr>
<td>Total test</td>
<td>98</td>
</tr>
<tr>
<td>Mathematics Scores--Effect of Study Habits</td>
<td>102</td>
</tr>
<tr>
<td>Fundamentals</td>
<td>104</td>
</tr>
<tr>
<td>Reasoning</td>
<td>107</td>
</tr>
<tr>
<td>Total test</td>
<td>110</td>
</tr>
<tr>
<td>Questionnaire on Interest and Attitudes</td>
<td>113</td>
</tr>
<tr>
<td>Subjects' interest in mathematics</td>
<td>113</td>
</tr>
<tr>
<td>Subjects' attitudes toward their achievement in the remedial mathematics course</td>
<td>118</td>
</tr>
<tr>
<td>Subjects' attitudes toward being required to take the remedial mathematics course</td>
<td>122</td>
</tr>
<tr>
<td>Subjects' comments about the course</td>
<td>124</td>
</tr>
<tr>
<td>Questionnaire on Programed Instruction</td>
<td>126</td>
</tr>
<tr>
<td>Small steps and logical sequencing</td>
<td>126</td>
</tr>
<tr>
<td>Checking responses</td>
<td>128</td>
</tr>
<tr>
<td>Chapter tests</td>
<td>128</td>
</tr>
<tr>
<td>Controlled learning</td>
<td>129</td>
</tr>
<tr>
<td>Conventional or programed instruction</td>
<td>130</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (Continued)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY AND CONCLUSIONS</td>
<td>131</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>145</td>
</tr>
<tr>
<td>APPENDIXES</td>
<td>150</td>
</tr>
<tr>
<td>Appendix A. Remedial Mathematics Student Questionnaire</td>
<td>151</td>
</tr>
<tr>
<td>Appendix B. Questionnaire on Programed Instruction</td>
<td>155</td>
</tr>
<tr>
<td>VITA</td>
<td>157</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comparison of experimental and control subjects with regards to the title of the last mathematics course they had taken</td>
<td>48</td>
</tr>
<tr>
<td>2.</td>
<td>Comparison of experimental and control subjects with regards to the number of years it had been since they had taken a mathematics course</td>
<td>50</td>
</tr>
<tr>
<td>3.</td>
<td>A content analysis of the mathematics test, conventional text and programed text</td>
<td>59</td>
</tr>
<tr>
<td>4.</td>
<td>The number of class periods not attended by experimental subjects who completed their programs early</td>
<td>67</td>
</tr>
<tr>
<td>5.</td>
<td>Chi-square contingency table comparing the responses made by experimental subjects and control subjects with respect to how much time they spent outside of class studying their mathematics assignments</td>
<td>68</td>
</tr>
<tr>
<td>6.</td>
<td>Chi-square contingency table comparing the responses made by experimental and control subjects to an item concerning the degree of difficulty of the text material</td>
<td>70</td>
</tr>
<tr>
<td>7.</td>
<td>A comparison of the means and standard deviation of the scores made by experimental subjects and control subjects on the mental ability test</td>
<td>71</td>
</tr>
<tr>
<td>8.</td>
<td>A comparison of the means and standard deviations of the scores made by experimental subjects and control subjects on the study skills inventory</td>
<td>73</td>
</tr>
<tr>
<td>9.</td>
<td>A comparison of the means and standard deviations of the scores made by experimental subjects and control subjects on the mathematics pretest</td>
<td>75</td>
</tr>
<tr>
<td>10.</td>
<td>A comparison of the means and standard deviations of the scores (unadjusted) made by experimental subjects and control subjects on the mathematics posttest</td>
<td>79</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>11.</td>
<td>A comparison of the means and standard deviations and changes in means and standard deviations from the mathematics pretest to the mathematics posttest (unadjusted)</td>
<td>80</td>
</tr>
<tr>
<td>12.</td>
<td>Correlation among the mental ability scores, study skills scores and pre and posttest mathematics scores for the experimental group and the control group</td>
<td>83</td>
</tr>
<tr>
<td>13.</td>
<td>A comparison of experimental and control subjects mean scores (adjusted) on the mathematics posttest</td>
<td>87</td>
</tr>
<tr>
<td>14.</td>
<td>Comparison of the mean scores made by subjects in the high low mental ability categories on the mathematics posttest fundamentals questions</td>
<td>92</td>
</tr>
<tr>
<td>15.</td>
<td>Comparison of the mean scores made by subjects in the high and the low mental ability categories on the mathematics posttest reasoning questions</td>
<td>96</td>
</tr>
<tr>
<td>16.</td>
<td>Comparison of the means and standard deviations of the scores made by high and low mental groups on the total mathematics posttest</td>
<td>99</td>
</tr>
<tr>
<td>17.</td>
<td>Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics posttest fundamentals questions</td>
<td>105</td>
</tr>
<tr>
<td>18.</td>
<td>Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics posttest reasoning questions</td>
<td>108</td>
</tr>
<tr>
<td>19.</td>
<td>Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics total test</td>
<td>111</td>
</tr>
</tbody>
</table>
LIST OF TABLES (Continued)

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.</td>
<td>Chi-square contingency table comparing experimental and control subjects in</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>terms of interest in mathematics prior to taking the remedial mathematics course</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Chi-square contingency table comparing mental and control subjects on the effect</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>of the remedial mathematics class on their interest in mathematics</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Chi-square contingency table comparing experimental and control subjects on how</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>they rated the interest of the remedial mathematics class with other mathematics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>courses they had taken</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Chi-square contingency table comparing experimental and control subjects on what</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>they thought their knowledge of basic mathematics was prior to taking the remedial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mathematics course</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Chi-square contingency table comparing experimental and control subjects on their responses to a question concerning the increase in knowledge of basic mathematics they thought they had obtained as a result of taking the remedial mathematics class</td>
<td>121</td>
</tr>
<tr>
<td>25.</td>
<td>Chi-square contingency table comparing experimental and control subjects' responses to an item asking them to rate the amount of mathematics they thought they had learned in the remedial mathematics course with the amount of mathematics they thought they had learned in other mathematics classes</td>
<td>122</td>
</tr>
<tr>
<td>26.</td>
<td>Chi-square contingency table comparing experimental and control subjects' responses with regards to their attitudes toward the remedial mathematics course requirement</td>
<td>124</td>
</tr>
</tbody>
</table>
ABSTRACT
The Use of Programed Texts for Remedial Mathematics Instruction in College
by
Charles C. White, Doctor of Education
Utah State University, 1969

Major Professor: Dr. James Shaver
Department: Secondary Education

Many universities and colleges have a considerable number of students enroll whose entrance examination scores indicate deficiencies in high school and pre-high school mathematics. The purpose of this study was to investigate the effectiveness of programed texts, as compared with conventional procedures, for teaching basic mathematics to remedial mathematics students. The effects of mental ability, study skills and attitudes on achievement through the use of programed texts also came under investigation.

For one quarter an experimental group of 73 subjects used a set of three linear programed texts for their sole mode of instruction in mathematics. A control group of 58 subjects were taught the same content material by traditional lecture-discussion procedures.
At the beginning of the 1965 Fall quarter, the subjects were given a mental ability test, a study skills and attitude survey and a standardized mathematics pretest. The subjects' scores on these three measures served as covariates for a covariance analysis of the mathematics posttest scores. Analysis of variance showed no significant differences (NSD) between the means of the experimental and control groups scores on the mathematics posttest. However, analysis of covariance showed a significant mean score difference in favor of the experimental group for the questions pertaining to mathematics fundamentals (computation) and NSD for the questions pertaining to reasoning (problem solving). The experimental group went from a mathematics pretest mean score grade placement of about 8.5 to a mathematics posttest mean score grade placement of about 10.5. The control group went from a mathematics pretest mean score grade placement of about 9.0 to a mathematics posttest mean score grade placement of about 10.5. The two different teaching methods did not bring about significant differences in the variability of the subjects' mathematics test scores.

The correlation between mental ability scores and mathematics test scores was moderate (about .50). As would be expected, the correlation between mathematics pretest and posttest scores was high (about .80). The correlation
between study skills scores and mathematics test scores was low (about .26 for the experimental group and about .04 for the control group).

Individual rates of progress, made possible by programmed texts, enabled a considerable number of students in the experimental group to complete the equivalent of a quarter's study in basic mathematics in less than a quarter's time.

A survey questionnaire concerning interest and attitude of the subjects toward mathematics, programmed instruction and the remedial mathematics course was given at the end of the quarter in which the study was conducted. Chi-square analysis of the responses to the questions generally showed the subjects' responses were independent of the type of instruction they had received.

The subjects were also asked to comment on what they thought were the most favorable characteristics of the course and what they thought were the least favorable characteristics of the course. The favorable comment listed most frequently by control subjects pertained to the slow group pace. They explained that it was the slow pace, coupled with a very understanding instructor, which enabled them to learn mathematics which they had missed in high school. However, it was also the slow group pace which drew the most number of control subjects' responses as to what they liked least about the course. The favorable
comment listed most frequently by the subjects who learned from programed texts pertained to the opportunity the programed texts had provided for each student to progress at his own rate. The unfavorable comment listed most frequently by the programed learning group pertained to no teacher-student interaction and no class discussion when programed texts were used.
CHAPTER I

DISCUSSION OF THE PROBLEMS

The Basic Problem

Increased enrollments at Utah State University and other universities throughout this country have presented some of these institutions with an increased number of applicants who show deficiencies in their mathematical training. If these students are to be admitted to a university or college, then what kind of program should the institution provide to help them overcome their deficiencies?

At the same time as administrators and instructors in these universities and colleges are faced with the growing remedial-student problem, a new technique of teaching called programmed instruction is being used and experimented with in number of public school systems, colleges, and universities. As early as 1962, Finn and Perrin (1962) reported that there were 59 manufacturers of teaching machines, and programmed textbooks were being produced by at least 65 programming groups. In 1964, Schramm (1964) found that there were over 190 reports of research on programmed instruction. Since then the number has continued to grow and one now finds many such reports in education and psychology journals.

Some of the research from the laboratory and the classroom, which will be discussed in the following sections of
this paper, makes it appear plausible that programed instruction may be an effective means of teaching basic mathematics to college students who have deficiencies in this area. For instance, the principles of programing--active responding, small steps, frequent repetition, immediate reinforcement, and individual pacing--which Skinner (1954) said should be considered most seriously in the development of programed teaching materials, may be particularly appropriate for remedial instruction. This seems reasonable since the remedial student, perhaps more than any other pupil, needs to be actively engaged with the subject matter. He may well be less able to generalize basic principles from particular instances and to distinguish particular instances as consequences of basic principles. Since his achievement test results indicate that he has not learned certain material as well as his fellow classmates, it may be that the remedial student needs to proceed more slowly and perhaps in smaller steps. Also, since learning may be more difficult for him, frequent repetitions should help to reinforce the desired response. Thus, if the learning situation is repeated frequently and the correct response is reinforced immediately, it seems likely that the learner may not only learn skills but also develop more confidence in his performance. Finally, since the student has been identified as needing remedial studies, individual pacing is probably imperative for him.
As plausible as it may seem that these principles apply particularly well for teaching remedial students, and in view of the abundance of research activity relating to these principles and programmed learning, it is somewhat surprising to find so few reports in the literature on the use of programmed materials for remedial instruction. Of the over 190 studies reported by Schramm (1964), few dealt with remedial students and there appear to be no reports available on the use of programmed materials for remedial mathematics instruction in a university or college.

This lack of knowledge regarding the use of programmed materials for remedial instruction has been noted in the literature. Briggs and Angell (1964) stated that there is a need for more information concerning the value of programmed materials in this area. In answer to the question, What research would you like to see done?, six users of programmed materials said they wanted research findings on the value of programmed materials in remedial instruction. (The Use of Programed Materials in the U. S. Schools, 1963). Their responses present the basic problem to which this dissertation was directed. On the one hand, some university and college officials are faced with a growing remedial student problem in mathematics; on the other hand, a relatively new technique--programed instruction--appears to be an effective means of teaching the remedial mathematics student. Yet, there is little evidence available directly supporting or
refuting the hypothesis that programed instruction is more
effective than traditional lecture and textbook instruction
for teaching basic mathematics to remedial students in
college.

The Problem as it Existed at
Utah State University

The remedial mathematics student problem has been of
cconern at Utah State University for some time. Instructors
in lower-division mathematics courses and some instructors
in other departments have reported that many students in
their classes were unable to solve problems that involved
basic arithmetic skills. These instructors either had to
avoid topics in their course which involved the use of
arithmetic skills or they had to use their class time for
instruction in basic arithmetic skills. At the same time,
some of the students were complaining that they were not
adequately prepared for the first course in mathematics
available to them at the university.

In December, 1964, a committee of the Utah State Uni-
versity Faculty Senate met to consider the remedial student
problem. This committee recommended that a non-credit
course in mathematics be required of entering students who
were deficient in basic high school mathematics. The com-
mittee gave the following reasons for recommending this
course:
1. Many students have not learned basic arithmetic and are overwhelmed by the first course in algebra. The non-credit course could be directed totally at student deficiencies.

2. Screening out those students with arithmetic deficiencies should raise the standards of the introductory and beginning courses in mathematics.

3. Such a course should help to permit a more non-discriminatory entrance policy. Students seeking admission to the university with discovered deficiencies may be admitted through the non-credit courses. (The Report of the Committee on Remedial Courses. Utah State University, December, 1964).

The committee's report was given to the head of the department of mathematics who was then faced with the problem of setting up the recommended remedial mathematics course. The writer of this paper, who was at the time an instructor in the mathematics department, was assigned to help design the recommended course and to participate as one of the instructors in the remedial student program. Those persons responsible for designing the course were particularly concerned with the question, how do you teach high school or pre-high school arithmetic to university students who have had the opportunity to learn mathematical skills but did not, or who have not used these skills for so long that they have forgotten them? The answer to this question was not known, but given the potential fruitfulness of programed instruction, an experiment to investigate its effectiveness seemed in order. It was decided to compare the achievement of students who learned from programed materials with the achievement of students who learned from a conventional textbook in a traditional class.
Subsequent Problems

The investigation of the problem introduced in the previous section gave the investigator an opportunity to consider some important aspects of learning theory that have been raised by other experimenters in the area of programed learning. For example, what are the effects of mental ability and study skills on achievement with programed instruction, as compared to their effects on achievement in a conventional class setting? Also coming under consideration in this investigation are the reactions of the learner to programed materials and the effect programed materials have on the attitude of the learner.

Programed learning and mental ability

The literature contains a number of conflicting reports as to whether programed instruction is more effective for slow, average, or bright students. Briggs and Angell (1964), Little (1964), and Borg (1961), all reported finding that slower students profited more than faster students from the use of programed materials. Gagne and his associates (1962) and Irion and Briggs (1957) reported no significant difference results when they studied the effect of ability on achievement in programed learning. Ashbaugh (1964), Beane (1965), Belcasto (1966), Lambert (1962), and Hoveland et al. (1949) all reported that I.Q. was significantly associated with the amount of information acquired from the programed
materials in their investigations. One subsequent problem, then, is presented by these conflicting reports. Nearly all the investigators reported that there is a need for more research on the relationship of mental ability and achievement in programed learning. In particular, they reported that research was needed in situations which employed distinct kinds of programs for certain kinds of students. The subjects in the ensuing study were students with indicated deficiencies in mathematics and the material used was a "Skinner Type" linear programed text.

Another problem which pertains to mental ability and programed instruction has to do with the kind of learning which is to take place. Programing may be an excellent instructional media for teaching factual material, but is it as effective as conventional procedures for developing insight, creativity and cognitive processes? One of the objectives of mathematics education is to teach the meaning of symbols and certain skills for operations on these symbols. This kind of learning requires storage, association and recall of certain content. Another objective of mathematics education is to try to develop those higher learning processes characteristic of problem solving. The latter kind of learning involves memory, and recall skills, but it also requires insight, cognition and creativity. Research is not only needed to determine if programed materials will help learners to remember facts and develop, but it is also
needed to determine how effective programed materials are in helping learners recall skills, but to develop skill in solving verbal or so called story problems.

**Programed learning and study skills**

A second subsequent problem arises when one wishes to consider the effect of study habits on achievement in programed learning. The subjects entering the remedial mathematics program at Utah State University have been identified as remedial in terms of their low scores in mathematics on an entrance examination. It seems plausible that these same students may also exhibit deficiencies in study skills, and these deficiencies would have an impact on learning. Borg and Cragan (1961) reported that they found programed materials to be a significant aid in learning educational psychology for students with low study-skills scores. However, Stone (1965) reported contradictory evidence. The research study reported in this dissertation gathered evidence bearing on the conflicting claims as to the effectiveness of programed materials in aiding students who have low study skills scores.

**Programed learning and attitudes**

A third subsequent problem considered in this research has to do with the attitude of the learner toward remedial studies and programed instruction. Students who have been identified as needing study in remedial mathematics apparently
have not had success in their previous study of mathematics and they may harbor feelings of fear and dislike for the subject. Also, people in general do not like to be reminded of their apparent weaknesses. The students in this study were not only reminded that they were weak in mathematics, but they were informed that they would be required to register for and pass a non-credit remedial course in mathematics if they were to obtain unconditional admission to the university. For these reasons, it seemed likely that many of these students would have attitudes of resentment and perhaps hostility toward the remedial course. The first problem having to do with attitude is that there is no information available concerning the attitude of subjects towards remedial courses which they have been required to take. A second problem is that there is little information available concerning the effect of programmed instruction on subjects' attitudes toward required courses after programmed materials have been employed to teach these courses.

**Summary of the Problems**

Probably in recent years no other topic in education has experienced the amount of research activity that programmed learning has. However, there have been too few reports of investigations into the use of programmed materials for remedial studies. At this same time, there is an increasing number of students entering universities and colleges whose
entrance examinations indicate that they are deficient in mathematics. There is a need to determine if programed materials are suitable for teaching basic mathematics to these particular students.

During the fall quarter of 1965, Utah State University required students who had deficiencies in mathematics, as indicated by their entrance examination scores, to take a non-credit course in basic mathematics. Programed texts were employed to teach an experimental group of these students.

A number of investigators have reported on experiments in which programed learning was compared with learning from conventional methods, but none of these reports had to do with the use of programed materials for instruction in basic mathematics in college. This is the main purpose of the present investigation.

Some researchers have reported on the effect of mental ability on achievement when programed materials have been incorporated as the means of instruction. The evidence from these reports has been conflicting and a need for new studies concerning the effect of mental ability on achievement through programed instruction has grown out of these conflicting reports. The present investigation will consider the effect of mental ability on achievement in basic mathematics when programed materials are employed to teach basic mathematics to college students.
There have also been reports of a conflicting nature regarding the value of programmed instruction as an aid in helping learners compensate for poor study habits. However, there is really very little information available having to do with the effect of study skills on learning from programmed instruction. The present investigation will examine the effect of the learners' study habits on learning basic mathematics through programmed texts.

Another area of programmed learning, in which there is limited information available, pertains to subjects' attitudes toward learning from programs. In the present investigation, the subjects' reactions to their programmed learning experience will be considered. Also coming under consideration, are the subjects' reactions to the non-credit remedial mathematics course requirement.

The next chapter has to do with those reports that are related to the present study.
CHAPTER II
RELATED STUDIES

Introduction

Even though programed instruction may be only in its infancy, the volume of studies published make a broad review of the research on programed instruction an unfeasible task. This review includes those research studies in which programed materials were used and which were closely related to the research problems identified in the previous section*. Included are studies done in elementary, secondary and college courses in which programed materials were employed for mathematics instruction; studies done in areas other than mathematics that pertain to mental ability, study skills, and attitudes as they relate to programed instruction; and a number of comparative studies in which learning from programed materials is compared with learning from conventional methods of instruction.

Comparison Studies

One of the first questions that arises when someone is contemplating the use of programed materials for the first time is, how well do students learn from programs as compared

*For a more general review see Schramm, 1964.
to how well they learn from other kinds of instruction? Schramm (1964) tabulated thirty-six reports comparing programmed learning with conventional classroom instruction. Sixteen of the studies took place in colleges, four in secondary schools, five in primary schools, ten with adults, and one with retarded children. Eighteen of the thirty-six comparisons showed no significant difference when the two groups were measured on the same criterion test. Seventeen showed significant superiority for the students using programs, and only one showed superiority for the classroom students. In addition, eight of the experimenters mentioned a time advantage, that is, the students using programmed materials were able to cover in less time basically the same subject matter as the classroom students.

Briggs and Angell (1964) discussed important experiments with reference to programed instruction in science and mathematics up to the year 1964. Of the nineteen comparison studies reviewed in this source, five were in science and fourteen were in mathematics. Findings of no significant difference were reported more often than significant differences. Two of the studies in mathematics favored programed instruction and in the other twelve either significance tests were omitted in the reports or the differences between the groups were not significant.

Some other method studies, although not in the area of mathematics, have important implications for this investigation. Wilson and Heywood (1964) used probationary, or what
they called, "subject A students," for their study. Their subjects were similar to remedial mathematics students at Utah State University, except that Wilson and Heywood's subjects were identified by low scores in English, rather than low scores in mathematics, on a college entrance examination. Wilson and Heywood reported that forty per cent of the students applying to the University of California do not pass the English section of the entrance examination and as a result they are required to take a non-credit English A class. Wilson and Heywood reported that the failure rate in the English A classes usually ranged from one-third to one-half of the number of students. When programed materials were employed to teach the classes in their study, all of the subjects using the programs passed the course with B or C grades. In this particular situation, programed materials proved to be very successful. Perhaps remedial students in college are sufficiently motivated to benefit from programed materials. However, it still remains to be determined what kind of student benefits most from programed materials and under what conditions programed materials are the most effective.

Two action research studies that are somewhat similar in design to that proposed for this dissertation were carried out by Spagnoli (1965a, 1965b). His first report indicated that he had matched two seventh-grade classes in two different schools in terms of I.Q. scores. One class in
each school was taught a unit in science for two weeks by a small-step linear program, while the other class was taught the same material for the same time by conventional methods. Analysis of covariance yielded no significant differences in achievement between the two groups in one school and a significant difference in favor of the programed learning group in the other. Spagnoli's second study was similar to his first except it involved sixth-grade students and a delayed retention test. His second study yielded no significant difference between the scores made by the groups on the posttest or on the retention test. Spagnoli (1965a) reported that teachers in the school system in which he carried out his investigations had been experimenting with programed materials for three years. Those experiences with programed materials which he judged were least successful, when compared with conventional methods of instruction, were those of a school years duration where the teacher remained detached from the program rather than becoming an active participant in the learning process. He judged the more successful programed teaching experiences to be those involving a specific topic of a subject area which was taught to students over a limited period of time. He did not report what criteria he had used to make his judgements.

Fincher (1965) found programed instruction to be more effective than conventional procedures when specific objectives were formulated and particular programs and tests
were developed to meet and measure the objectives. In an opinion article, May (1965) claimed that no fixed programming pattern can take care of the objectives in mathematical education. He included the development of student responsibility for controlling the learning process as one of the objectives of mathematics education. May contended that programed materials inhibit initiative, independence, and responsibility of the learner for controlling his learning experience. He claimed that programed materials would be of greatest value as large libraries of brief units focused on specific student difficulties.

Three other experimenters expressed their opinions on the use of programed materials. Kemp (1964), after comparing a unit of programed instruction with traditional instruction in a mathematics refresher course for navy personnel, recommended that the entire refresher mathematics course be programed and that the programs be used in place of the present instructional methods. A superintendent of schools, Houston (1965), claimed that many students using programed materials in his district will finish four years of high-school work in two and one-half years. He did say that some students "bog down" when allowed to go at their own pace and a teacher must set the pace for them. Another superintendent of schools, Bell (1962), claimed that in his district programed materials provided sufficient motivation and interest to keep approximately seven hundred students committed to the program on a daily fifty-minute
basis. He also reported that these materials made it possible for some students to complete a year's work in one semester and that some students progressed as much as eight times faster than others.

Teachers may not be as optimistic about individual rates of learning made possible by programed materials as the two superintendents above appear to be. Frey (1965) reported that some teachers feel uneasy with programed materials as they view thirty different students proceeding at thirty different paces. Of particular concern to the teachers in Frey's investigation were evaluation problems and the possibility of loss of control over the teaching process. Frey's study focused attention on another question, what role should the instructor play in the learning process? This question is still open. It has been claimed that programed instruction is able to free the teacher for the more creative aspects of teaching. Guggenhiem (1965) would like these creative aspects of teaching identified. He raised the question, where is the teacher to be relocated in the teaching process? He reported that his investigation of most available programs revealed that they were closed instructional systems consisting of the student and the programs without access points allowing the teacher to participate.

Bartz and Darby (1966) found that when subjects with programed materials were unsupervised, they did not benefit
any more from the materials than unsupervised subjects using conventional text materials. Specifically, the advantage of individual rates of learning was not realized under the unsupervised conditions. Bartz and Darby also reported that the subjects who used small-step linear programs seemed to develop illusions of competence and that frequent classroom testing was necessary to modify the subjects' performance expectations. Higgins and Rusch (1965) found that subjects who had used small step programs were not as able to adjust to the increasing difficulty of the items on a criterion test as were subjects who did not use programs. Bartz and Darby, as well as Higgins and Rusch, recommended that programed materials should have some more difficult problems included in them, and that the students using programed materials should be tested frequently.

A summary of the method studies comparing programed instruction with conventional classroom instruction reveals that the programed learning groups did at least as well as the conventional control groups. In fact, there were more reports favoring programed instruction than there were reports favoring the conventionally taught groups. However, nearly all the investigators of the method studies reported that there is a need for additional research having to do with relations between the characteristics of the learner and the effectiveness of programed instruction. The review now turns to some of the reports on programed instruction in which characteristics of the learners were studied.
Mental Ability Studies

Since programed materials as a teaching device have been demonstrated to be at least as effective as conventional procedures for some objectives, some researchers have directed more of their attention to the variables related to learning with programed instruction. One such variable is ability. Carr (1960) claimed that it was the relative ineffectiveness of traditional techniques of instruction to cope with the wide range of student ability in the typical classroom that led the pioneers of programed materials like Crowder and Skinner to develop their programing techniques. Skinner (1954) said that even if a single teacher devoted all her time to a single child she could not provide the reinforcement necessary to bring about the most effective control of his learning. Skinner (1961) also said that by trying to teach more than one student at once we harm both fast and slow learners. Skinner believes that it is the slow learner who suffers the more disastrous consequences. He points out that a student who has not mastered a first lesson is less able to master a second and that a small difference in speed may cumulatively exaggerate the learner's shortcomings and eventually result in an immense difference in comprehension. Carr (1960) explained that recognition of many teachers' inability to work efficiently with more than a few students at a time has caused psychologists and educators to look hopefully to programed instruction.
When researchers have studied the relationship of mental ability to achieve with subjects taught by programed materials, most of them have reported significant positive correlations. Belcastro (1966) reported that he found mental ability and achievement to be significantly correlated when he used programed materials to teach algebra. Fincher (1965) reported a significant relation between mental ability and achievement when he investigated the use of programed materials for instruction in arithmetic. Hatch (1962) reported that academic intelligence predicted achievement in programed instruction as well as it did for conventional instruction for the subjects in his investigation. Lambert (1962) used a linear programed text on sets, relations, and functions to teach 552 ninth-grade students. He reported that intelligence was significantly associated with the amount of information acquired from the program. Shaver and White (1966) reported that they found subjects' scores on the Otis Mental Abilities Test correlated significantly with achievement in an algebra course when a linear programed text was employed to teach the course. Frey (1963) found that there was merit in grouping according to ability when programed materials were presented in a group paced manner in the classroom.

Ashbaugh (1964) used two different kinds of programs to see what effect mental ability had on different kinds of response modes in programed learning. One program required
the subjects to write out their responses to the frames (overt response). The other program required that the subjects merely think the answers (covert response). Ashbaugh reported that there was a significant correlation between mental ability and achievement for both kinds of programs, but there was no significant difference between the correlation of mental ability and achievement for the two different kinds of response modes. Beane (1965) employed both linear programs and branch programs to teach high school students a unit in plane geometry. He found significant differences in achievement in favor of the high mental ability groups regardless of which program they had used. He also reported that both the high and the low ability students expressed a preference for learning from the linear programed texts over the branching texts.

The findings pertaining to the kind of programs and the kind of response mode are relevant to this review since some psychologists have questioned the small-step immediate-reward approach to learning that characterizes linear programs of the kind employed for this investigation. Smith and Moore (1962) expressed the concern that over-cueing may reduce the active participation of the student, thereby reducing learning efficiency. They explain that immediate knowledge of results may be nothing more than an additional cue for the response of the next item, and that with too many cues the response may become automatic with little learning taking place. Their observation may help to
explain some of the reports (Schramm, 1964; Henderson, 1963) of boredom that have come from students who have worked through long programs with small steps. Beane (1963) reported that his subjects expressed attitudes more favorable to learning from a small-step linear programed text over regular classroom instruction midway through the program, but that seven weeks later this attitude had changed to a neutral one.

Dessart (1962), Coulson (1962), Gagne (1962), Hassinger (1965), Shey (1961 and Spagnoli (1965a) reported that they found no significant relation between mental ability and achievement when subjects were taught by programed materials. However, an examination of the programs used in the latter three studies reveals that they were so short (120 minutes to 5 hours) that perhaps they left little room for intelligence to be an important factor in the learning. Briggs and Angell (1962) warn the reviewer of studies in programed learning that even though the investigators appear to exhibit great concern for proper experimental design, they often neglect an anatomical study of the program itself. Briggs and Angell concluded, after reviewing a number of conflicting reports on the effect of mental ability on programed learning, that it appears plausible that the more closely a program resembles a textbook the higher will be its correlation with mental ability.
Some investigators reported that their lower ability subjects benefited more than their other subjects from the use of programmed materials. Borg and Cragan (1961), after finding that their experimental subjects who used teaching machines for study aid made significantly greater gains than their control subjects who did not use the machines, next pursued the effects of verbal ability on achievement. They found that when the lower 50 per cent of the experimental group, in terms of verbal ability, used teaching machines for study aid, they did as well as the upper 50 per cent of the subjects in the control group who did not use the machines. Gorow (1961) found that when he compared the use of programmed materials with the use of conventional materials, there were no significant differences in achievement between the middle groups of students in the experimental group and the control group. However, he reported that the high-ability and low-ability students did significantly better in the programmed learning situation than did the high and low-ability groups in the conventional classes.

Other investigators have reported that programmed materials have offered valuable help for slower students and seem to be of considerable worth to remedial student classes. Creswell (1967) reported that when remedial mathematics students in grades 7-11 (grade placement between 4 and 7 in arithmetic) were identified and taught basic arithmetic by programmed materials for one school year, they gained 1.6 years on a grade placement scale. Smith (1960) reported
that slow learners who used programed materials in all of their subjects made 59 per cent of a school year's increase in other subjects and 19 per cent of a year's increase in arithmetic over what they had gained the previous year in which programed materials were not used. Smith also noted a considerable reduction in the subjects' negativism toward mathematics when programed materials were employed.

**Study Skills Studied**

One would probably expect that students with better study habits would make greater achievement gains than students with poor study habits, other things being equal. Borg and Cragan's (1961) findings supported this assumption for subjects in both their control groups and their experimental groups before programed materials were used. When teaching machines were employed in the experimental group, it was reported that the upper 50 per cent of the group on study habits did not make significantly greater gains than did the lower 50 per cent. It was also reported that when experimental subjects in the lower 50 per cent on study skills used a teaching machine as a study aid, they made slightly greater achievement gains than the upper 50 per cent of the control group who did not use the machines. Borg and Cragan concluded that the teaching machine was a valuable teaching aid and that the teaching machine did help compensate for poor study habits.
Skinner (1961) in his report "Why We Need Teaching Machines," presented several reasons he thinks teaching machines aid the learner. First, he explained that the user of a teaching machine remains active. If the learner stops, the program stops. Second, Skinner said that the learner gets immediate and frequent reinforcement which sustains interest. Third, he reported that each student is free to proceed at his own rate. Finally, he concluded that the student is able to follow a program without breaks or omissions and he is therefore able to take up wherever he leaves off. These conditions are probably desirable for almost any learner, but it seems that they would be especially valuable for an individual who does not have good study habits.

It was disappointing to find that more investigators have not reported on the effects of programmed materials on achievement as they relate to study habits. Borg and Cragan (1961) stated that they were not aware of any other experiment carried out in the area of programmed instruction and study skills. Since 1961 there appears to be only one other study (Stone, 1965) in which the possible effects of programmed materials as a compensation for poor study habits was considered. In his investigation, Stone found that study habits yielded no differential effects on performance with an experimental group using programmed materials and a control group being taught by conventional procedures.
Subjects in both Borg and Cragan's investigation and Stone's investigation were college students and the subject matter in both of their experiments was educational psychology. Furthermore, the same instrument was employed in both studies to measure the subjects' study skills. The differences between the two investigations were that Borg and Cragan's subjects used a teaching machine as a study aid along with conventional instruction, whereby Stone's subjects used programed texts for the entire mode of instruction. Also, the subjects in Borg and Cragan's study were encouraged to use texts and teaching machines outside of class whereby Stone's subjects were not allowed to use the programed texts or the conventional texts outside of class. The differences in procedure may account for the different findings, and the results of these two studies might suggest that programed materials are best suited for study aids rather than for the complete teaching process. However, there has not been enough research done on programed instruction and study skills to establish any highly probable theory regarding the effectiveness of programed materials as a compensation for poor study habits.

**Attitude Studies**

Three studies have been reported in which most of the subjects under investigation indicated favorable attitudes toward their programed learning experience. Wilson and Heywood (1964) used programed materials to teach punctuation
and spelling to remedial college students. They reported that 67 per cent of their subjects expressed favorable attitudes toward learning from programs while 22 per cent expressed negative attitudes toward their programed learning experience. McGarvey (1962) used a "Temac" first year algebra program to teach high school students who had been identified as underachievers. McGarvey reported that the students' reception of programed materials was generally favorable, that motivation and discipline problems were nil, and that both the fast and the slow students reacted favorably to programed learning. Banghart (1963) reported that fourth-grade students expressed favorable attitudes toward programed instruction in arithmetic. The most favorable characteristic reported was the freedom that programed materials provided for each student to go at his own rate.

Three other studies (Hartley, 1965; Beane, 1963; and Kellems, 1965) indicated that the subjects' initial reaction to learning from programs had been quite favorable, but that after the subjects had used the programs for a few weeks their attitudes toward programed learning changed from favorable to neutral. Hartley used a branching program with one group of subjects and a linear program with another group to teach mathematics to high school students. He reported finding no significant difference between the attitudes of the subjects in the two groups toward programed learning after they had used the programed materials for four weeks, and again after they had used them for thirteen
weeks. However, he did report finding a decline in the favorableness of the subjects' attitudes toward programmed learning in both groups from the time he measured them at four weeks to the time he measured them again at 13 weeks. Bean and Kellems also reported that their subjects' attitudes toward programmed learning declined from favorable at the beginning of the course to neutral later in the course. In fact, Kellems reported hearing complaints of boredom and excessive page turning from some of the subjects using programmed texts in his experiment.

Other researchers have investigated the relation between student performance and student attitude toward programmed learning. It seems likely that their investigations would reveal a high correlation between attitude toward programmed learning and achievement for subjects who had learned from programs. This seems reasonable since fast students with good retrieving and recall faculties are allowed to proceed at their own fast pace when employing programmed instructional materials. These students may associate part of their success with this freedom to go at their own rate. Slower students, when allowed to proceed through a program at their own rate, are perhaps less likely to get lost than they would if they had been in a traditionally group-paced class. They may associate their success or improved performance to individual pacing. Finally, if a student's need to achieve is satisfied, he may associate
some of this intellectual satisfaction with the method by which he learned. As feasible as the expectation of a high correlation between attitude toward programed materials and achievement for subjects who had learned from programs may appear, the research does not bear it out. Eigen (1963) reported that he found no relationship between students' attitudes toward programed learning and how much they learned from the program. Doty and Doty (1964) reported a lack of correlation between achievement and attitude toward programed instruction.

May (1965) put forth the following explanation of the lack of correlation between achievement in mathematics and attitude toward programed learning. People generally study mathematics for two reasons. One is their belief that mathematics will be useful to them. The other is the intellectual satisfaction that comes from insight and accomplishment, for example, cracking a tough problem. Both of these reasons are based on finding solutions to non-trivial problems, and these are not found in most programs.

It may be that what has been looked at as the virtues of programing contains some of its faults. The Skinnerian programer goes to a great deal of planning to fragment the subject matter into smaller and smaller steps until each response called for is so easy that it is almost certain to be correct. But, the research seems to indicate that good students may not be motivated to respond to trivial questions. While students may get some satisfaction from
always moving ahead, the reports of boredom and excessive page turning make one wonder if moving ahead by small steps is motivation enough.

**Summary of Related Studies**

A summary of the method studies, in which experimental groups using programed materials were compared with control groups not using programed materials, indicates that the two groups usually do not perform significantly different on criterion tests. There were a few more reports favoring programed instruction than there were favoring the conventionally taught groups. This finding was especially true when time was considered as one measure of effectiveness and when the teacher had an active part in the learning process. Another factor which was reported to bring about the more successful use of programed materials was that of selecting specific objectives to be accomplished and then writing or choosing specific programs designed to meet these objectives.

The use of programed materials by slow, average and bright students has been studied. Most of the studies have indicated a positive correlation between mental ability and achievement through the use of programed instruction. The majority of investigators who used programed materials to teach remedial students reported success, that is, their subjects learned more by programed instruction than they
had by conventional procedures. Several teachers who had used programed instruction for remedial students recommended that other teachers faced with remedial student problems should try programed materials. Unfortunately, the literature was void of any comparison reports on the use of programed materials for teaching mathematics to remedial students in college.

There were only two investigators who considered the effects of study skills on learning through programed instruction. These reports were conflicting and suggested the need for additional research in this area.

Studies of the attitudes of the learner toward programed materials indicate that students' reaction to these materials generally are favorable. The favorable comments reported most frequently had to do with the opportunity which programs had given the students to go at their own rate. The criticisms of the programed materials reported most frequently were that the questions were too easy and that there tended to be no interaction between the students and the teacher.

Some of the implications the review of the related studies had for the present investigation are:

(1) Since a small-step linear program was to be employed for instruction, a well-supervised program including frequent testing should be incorporated.
(2) Since there are conflicting reports concerning the effect of mental ability on learning through programed materials, this study should investigate the effect of mental ability on learning facts and developing problem solving ability in mathematics through programed instruction.

(3) Since there are only two reports on the effect of study habits on learning through programed instruction and these were conflicting, this study should examine the effect of study habits on learning mathematics by remedial students in college.

(4) Since the subjects under investigation in this study may, as a result of their being placed in a non-credit remedial course, have attitudes of resentment and perhaps hostility toward the course and the content, the study should compare how the two different treatments—conventional instruction and programed instruction—effect the attitude of the subjects toward the remedial course and the subject matter.

(5) Since there were no studies reported on the use of programed materials for teaching mathematics to remedial students in college and since there is an increasing number of students entering universities and colleges who need remedial training in
mathematics, this study should investigate the effectiveness of programed materials as compared to conventional procedures as a means of teaching basic mathematics to this particular kind of student.
CHAPTER III
OBJECTIVES AND HYPOTHESES

Achievement and Variability

The primary objective of the investigation was to test the effectiveness of programed materials, as compared with conventional teaching procedures, as a means for teaching basic mathematics to remedial students at Utah State University. This effectiveness was measured in terms of achievement on a standardized mathematics test. Final mean scores made by experimental and control subjects were compared for significant results.

A second objective was to determine if the two different teaching methods brought about significant differences in variance as measured by the standard deviations of the scores made by experimental and control subjects on the mathematics test. Programed materials emphasize drill and the mastery of basic operations, which may benefit the slower students more than the brighter students and thus reduce the variance of the group from pretest to posttest.

The following null hypotheses were formulated to put the objectives pertaining to achievement and variance in testable form.

1.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals
between experimental subjects having programmed instruction and control subjects in a conventional class.

2.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects having programmed instruction and control subjects in a conventional class.

2.2 There will be no significant difference in variance on a mathematics posttest of reasoning between experimental subjects having programmed instruction and control subjects in a conventional class.

3.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects having programmed instruction and control subjects in a conventional class.

3.2 There will be no significant difference in variance on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects having programmed instruction and control subjects in a conventional class.

Mental Ability

Another objective was to investigate the effect of mental ability on achievement when subjects are taught by programmed and conventional procedures. Specifically, the research
was aimed at investigating if programed materials of the kind employed in the study are best suited for the remedial mathematics training of students who score above the median on a mental ability test or students who score below the median on this test.

The following null hypotheses pertaining to mental ability and achievement in mathematics fundamentals through programed instruction and through conventional instruction were formulated.

4.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a mental ability test and experimental subjects who scored below the median on the mental ability test.

4.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test.

4.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test.
4.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored below the median on a mental ability test and control subjects who scored below the median on the mental ability test.

The following null hypotheses pertaining to mental ability and achievement in mathematics reasoning through programed instruction and through conventional instruction were formulated.

5.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on the mental ability test and experimental subjects who scored below the median on the mental ability test.

5.2 There will be no significant difference in mean scores on a mathematics posttest of reasoning between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test.

5.3 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test.
5.4 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored below the median on a mental ability test and control subjects who scored below the median on the mental ability test.

The following null hypotheses pertaining to mental ability and achievement in mathematics fundamentals and reasoning (total test) through programmed instruction and through conventional instruction were formulated.

6.1 There will be no significant difference in mean scores on a mathematics posttest between experimental subjects who scored above the median on a mental ability test and experimental subjects who scored below the median on the mental ability test.

6.2 There will be no significant difference in mean scores on a mathematics posttest between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test.

6.3 There will be no significant difference in mean scores on a mathematics posttest between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test.

6.4 There will be no significant difference in mean scores on a mathematics posttest between
experimental subjects who scored below the median on a mental ability test and control subjects who scored below the median on the mental ability test.

**Study Skills**

Another objective of the study was to investigate the effect of study habits on learning when subjects are using programmed materials. Specifically, this phase of the investigation was carried out to see if programmed materials would help compensate for poor study habits in the area of remedial mathematics education.

The following null hypotheses pertaining to study habits and achievement in mathematics fundamentals through programmed instruction and through conventional instruction were formulated.

7.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits.

7.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between control subjects who scored above the median on a survey of study habits and control subjects who scored below the median on the survey of study habits.
7.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a survey of study habits and control subjects who scored above the median on the survey of study habits.

7.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits.

The following null hypotheses pertaining to study habits and achievement in mathematics reasoning through programmed instruction and through conventional instruction were formulated.

8.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits.

8.2 There will be no significant difference in mean scores on a mathematics posttest of reasoning between control subjects who scored above the
median on a survey of study habits and control subjects who scored below the median on the survey of study habits.

8.3 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on a survey of study habits and control subjects who scored above the median on the survey of study habits.

8.4 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits.

The following null hypotheses pertaining to study habits and achievement in mathematics fundamentals and reasoning (total test) through programmed instruction and through conventional instruction were formulated.

9.1 There will be no significant difference in mean scores on a mathematics posttest between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits.

9.2 There will be no significant difference in mean scores on a mathematics posttest between control
subjects who scored above the median on a survey of study habits and control subjects who scored below the median on the survey of study habits.

9.3 There will be no significant difference in mean scores on a mathematics posttest between experimental subjects who scored above the median on a survey of study habits and control subjects who scored above the median on the survey of study habits.

9.4 There will be no significant difference in mean scores on a mathematics posttest between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits.

Interest and Attitudes

Another set of objectives was to compare programed and conventional instruction in terms of their effect on the learner's attitude toward mathematics and the remedial course. One such objective was to determine if one method of instruction had more effect than the other on the learner's interest in mathematics. Another objective was to compare the experimental and control subjects' opinions as to how much they thought they had achieved in the remedial course. The third objective in this set was to compare experimental and control subjects on how they rated the effectiveness of the remedial
mathematics course compared to the effectiveness of other mathematics courses they had taken. A subject's interest and feeling of achievement in a class may be related to his attitude toward having to take the class. The final objective in this set was to compare experimental and control subjects' attitudes toward having to take the non-credit remedial mathematics course.

A questionnaire pertaining to the subjects' interest, achievement and attitude toward the remedial mathematics course was developed and administered to all the subjects in the experiment. Results of the subjects' responses to the items on the questionnaire were compared by chi-square analysis. Null hypotheses of independence were formulated to put the objective pertaining to interests and attitudes in testable form. The chi-square tables are shown in Chapter V. The hypotheses are stated immediately preceding the chi-square tables and they are accepted or rejected immediately following the results shown in the tables.

**Subject's Reactions to Programed Instruction**

At the termination of the remedial mathematics course, a group of experimental subjects had completed a quarters study in basic mathematics in which programed texts served as the entire mode of instruction. A final objective was to obtain some measure of the reaction of these students to their programed learning experience. No hypotheses based on
students' reactions to programed learning were formulated; however, the subjects were asked to respond to a set of questions regarding the characteristics and the use of programed texts. These questions and a tally of the subjects' responses to the questions are included in Appendix B.
CHAPTER IV
PROCEDURE

Selection and Characteristics of the Sample

Freshmen applying to Utah State University and transfer students who have not successfully completed 45 quarter hours of credit or its equivalent from an accredited institution of higher education are required to submit scores from the American College Testing Program Examination (ACT) to the Office of Admissions and Records of the University. Students, regardless of their high school grade point average, are required to register for a remedial non-credit mathematics course if their predicted college mathematics grade point average, based on ACT scores and high school grades in mathematics, is less than 1.40 on a 4 point scale. In the summer of 1965, the Office of Admissions and Records at Utah State University identified over 200 applicants for fall quarter 1965 whose predicted grade point average in mathematics was below 1.40. These applicants were notified by the Office of the Registrar of their deficiency in mathematics. They were informed that they could enter the University as probationary students and progress to a regular student stature pending successful completion of the remedial mathematics course.

In addition to their remedial mathematics placement, some of these students were also given remedial English
placement. If an applicant is placed in both remedial English and remedial mathematics, then he is also assigned to a non-credit remedial study skills class.

During the Fall Quarter of the 1966-67 academic year at Utah State University, the Department of Mathematics made available two sections of remedial mathematics—one at 11:30 A.M. and one at 2:30 P.M. At the completion of registration, 144 subjects had registered for the remedial mathematics course. Eighty-two students had registered for the 11:30 section, while sixty-two registered for the 2:30 section. The students were free to choose their section. As far as the investigator was able to determine, there were no required class conflicts that would have affected the subjects' choice of sections. The difference in the number of students registering for each section can probably be explained by the fact that morning classes are generally preferred over the afternoon classes.

The investigator was assigned as the instructor for the 11:30 section which he designated the experimental group. Programed textbooks were employed for the mathematics instruction of all the students in the experimental group. Another mathematics instructor was assigned to the 2:30 section which was designated the control group. The instructor in the control group used conventional teaching procedures and a conventional textbook for the mathematics instruction of the control subjects.
Since one of the objectives of the experiment was to see how much basic mathematics a remedial mathematics student in college could learn from a programed text, the role of the instructor in the programed learning group was purposely minimized. The instructor checked roll, administered tests, and maintained order in the classroom. He did answer a few questions on an individual basis, but this was all. He did not lecture, direct or guide discussions, make assignments, or check assignments. In other words, he purposely tried not to interfere in the programed learning experience of the students. Since the role of the instructor in the experimental group was so limited, a comparison of the instructors and the instructor variables was not deemed essential to the investigation.

None of the subjects were told that they were participating in an experiment, but it is possible that some of the subjects in the experimental group were affected initially by the novelty of the programed texts. However, since the programed materials were used for the whole quarter, there was time for the novelty to wear off.

At the completion of the remedial mathematics course, subjects in the experimental and the control groups were asked to respond to questions concerning their previous mathematics training, their interest in mathematics before and after completion of the remedial course, their feeling of achievement in the course, and their reaction to the
remedial mathematics classes. In addition, subjects in the experimental group were questioned concerning their reaction to learning from programed texts. A copy of each questionnaire and a tally of the responses made by experimental and control subjects is included in Appendices A and B. Some of the data gathered from the first questionnaire is presented here as it is useful in providing a more complete description of the sample.

Table 1 shows a comparison of experimental and control subjects responses to the question, what is the title of the last mathematics course which you took?

Table 1. Comparison of experimental and control subjects with regards to the title of the last mathematics course they had taken

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
<td>N. %</td>
</tr>
<tr>
<td>Exp.</td>
<td>3 4</td>
<td>5 7</td>
<td>7 10</td>
<td>31</td>
<td>12 24</td>
<td>7 10</td>
<td>2 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cont.</td>
<td>1 2</td>
<td>7 12</td>
<td>20</td>
<td>36</td>
<td>20 36</td>
<td>5 9</td>
<td>2 3</td>
<td>1 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4 3</td>
<td>12 9</td>
<td>27</td>
<td>21</td>
<td>51 39</td>
<td>23 18</td>
<td>9 7</td>
<td>2 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows that there is a systematic difference between the classes checked by the subjects in the experimental group and those checked by the subjects in the control group. For example, there were twenty-eight subjects in the control group who checked either geometry, second year
algebra or trigonometry as the last mathematics class which they had taken, whereby only fifteen subjects in the experimental group checked these classes. On the other hand, fifty-eight subjects in the experimental group checked either high school general math, ninth-grade algebra, ninth grade general math, or eighth grade general math as the last mathematics class which they had taken, whereby only twenty-eight subjects in the control group checked these classes. The data indicate that even though the control group was smaller than the experimental group, it nevertheless contained more subjects than the experimental group who had studied mathematics beyond first year algebra and general mathematics in high school.

Thirty-three per cent of the subjects in the experiment indicated that they had taken either geometry, second year algebra, or trigonometry in high school. One wonders why these students performed so poorly on the mathematics section of the college entrance examination so as to be placed in the remedial mathematics program.

As one might expect, high school general mathematics was the course which most of the students checked as the last mathematics course they had taken in high school. However, all of the mathematics courses listed were checked by some students, and the range is considerable--eighth grade arithmetic through trigonometry.
Another question asked each subject, how many years has it been since you took a mathematics course? Table 2 shows a comparison of the responses made by the subjects to this question.

Table 2. Comparison of experimental and control subjects with regards to the number of years it had been since they had taken a mathematics course

<table>
<thead>
<tr>
<th></th>
<th>More than 10 years</th>
<th>5 to 10 years</th>
<th>3 to 5 years</th>
<th>2 to 3 years</th>
<th>Less than 2 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
</tr>
<tr>
<td>Exp.</td>
<td>1 1</td>
<td>11 15</td>
<td>21 29</td>
<td>17 23</td>
<td>23 32</td>
</tr>
<tr>
<td>Cont.</td>
<td>5 9</td>
<td>3 5</td>
<td>19 34</td>
<td>12 21</td>
<td>17 30</td>
</tr>
<tr>
<td>Total</td>
<td>6 5</td>
<td>14 11</td>
<td>40 31</td>
<td>27 21</td>
<td>40 31</td>
</tr>
</tbody>
</table>

Except for the ten year category and the between 5 and ten year category, the two groups were quite comparable on this item. The average time the subjects in the experimental group indicated it had been since they had taken a mathematics class was 2.5 years and for the control group the average time was 2.9 years. The combined average was 2.7 years. Notice that the range is considerable, from less than 2 years to more than 10 years.

Another question asked the subjects was, what was the size of your high school graduating class? Only 38 subjects,
out of 129 responding reported they had graduated from a high school in which the graduating class was less than 200.

During the first part of the 1965 fall quarter, in which the study was initiated, the Counseling and Testing Service at Utah State University administered a mental-ability test and study-skills test to all the subjects in the remedial courses. These measures are discussed in the measures section of this chapter. An analysis of the results of the scores on these instruments is presented in the next chapter on findings. The reason for including mention of these measures here is that they were used to partition the subjects' scores into high and low categories for purposes of analysis. The mental-ability test was used to classify the subjects' scores into a high mental ability (above the median) experimental category, a low mental ability (below the median) experimental category, a high mental ability (above the median) control category, and a low mental ability (below the median) control category. The study skills test was used to classify the subjects into a high study skills (above the median) experimental category, a low study skills (below the median) experimental category, a high study skills (above the median) control category, and a low study skills (below the median) control category.
The programed textbooks

The programed learning materials selected for use in the experimental class was set of three linear programed texts (Bobrow, 1962). In the teacher's manual for these materials, the author states that the goal of this course is to teach the arithmetic of the whole numbers and the rational numbers, and to present some of the more important applications of this arithmetic. Of primary concern in the selection of this set of texts was the appropriateness of the content for remedial mathematics instruction and the degree to which the content was sampled by the mathematics achievement test.

The material in the set of programed texts is presented in a sequence of sentences or paragraphs, called frames, each of which contains one or more blanks to be filled in by the student. The purpose of the blanks is to provide a means by which the learner actively engages in the material he is reading. This is the method of programing advocated by Skinner (1961) who reported that to acquire behavior the student must engage in behavior. After the student has filled in a blank, a previously concealed correct response can be revealed so that the student can receive immediate reinforcement for a correct response and a blocking of an incorrect response. Skinner (1961) believes this format provides frequent and immediate reinforcement, allows the
learner to proceed at his natural rate, and presents the learner with a logical, coherent sequence of information.

The conventional textbook

The textbook selected for use in the control group was a conventional arithmetic book by Brumfield, Eichols, Shanks and O'Daffer (1963). In the preface to their book, the authors explain that they designed the book for the instruction of students whose mathematical backgrounds are insufficient for an algebra course. Throughout the text, systematic explanations of the algorithms used in computing with whole numbers and rational numbers are included. No algebraic skills are presupposed for students using the text; however, some symbolism of algebra is present in the exposition.

The primary concern in the selection of this text was the appropriateness of the content for remedial mathematics instruction and the degree to which the content corresponded with the content of the programed texts and the mathematics achievement test. A content analysis comparing the two texts and the achievement test is included in this chapter after a discussion of the measures employed in the investigation.

Measures

The mathematics achievement test

The primary measure for assessing the effectiveness of programed texts for instruction in remedial mathematics was
the subjects' achievement in basic mathematics. The instrument employed for measuring achievement was the California Mathematics Test, Grades 9-14. Alternate forms, W and X, of this test were used for a pretest and a posttest respectively. The California Mathematics Test was selected on the basis of its high content validity with the two textbooks used in the study. Out of the total 140 questions in this test, 104 sampled content found in both the programed texts and the conventional text. Of the other 36 questions, 5 asked for information that was not covered in the programed text and the other 31 asked for information that was not present in the programed text or the conventional text. These 36 questions were included in the test, but the subjects' responses to these questions were deleted from the analysis.

The manual which accompanies the California Mathematics Test reports the reliability coefficient for this measure, as based on a single grade range (grade 11) only, as .95. The subjects comprising the sample for the present investigation were not in grade 11. Furthermore, only 104 of the total 140 questions, which were used to establish the .95 reliability coefficient, were employed in the analysis. Therefore, it was necessary to establish a new coefficient of reliability for the new sample and the 104 questions which were used. This was done by using the Kuder-Richardson Formula 21. A reliability coefficient of .86 was obtained
for the 104 questions used in the analysis of the pretest. A reliability coefficient of .89 was obtained for the 104 questions used in the analysis of the posttest.

The mathematics test questions were classified by the investigator into two sets. One set, which contained 72 questions, was used to measure fundamentals (computation) and the other set which contained 32 questions was used to measure reasoning (problem solving). The reliability coefficients determined by the Kuder-Richardson Formula 21 for the fundamentals pretest and posttest were .84 and .88 respectively for the experimental group and .88 and .89 for the control group. For the reasoning questions the reliability coefficients for the pretest and the posttest were .47 and .64 respectively for the experimental group and .54 and .64 for the control group.

The mental ability test

The instrument employed to measure the subjects' mental ability was the Army General Classification Test (AGCT). The results of this test were used to classify subjects within the experimental group and the control group into high and low mental ability groups as described in this chapter under the characteristics of the sample. The AGCT was developed to screen large numbers of army inductees in terms of their intellectual aptitude. Since its development, various attempts have been made to adjust the standard score scale of this test to make it representative of the
general population, but according to a review by Dailey in Burros (1963; p. 281), appropriate adjustments have not been accomplished. However, percentile scores are available for males and high school students.* An analysis of the scores made by experimental and control subjects on the AGCT is presented in the next chapter. A reliability coefficient of .86 was obtained for the AGCT as determined by the Kuder-Richardson Formula 21.

The study skills survey

The Brown-Holtsman Survey of Study Habits and Attitudes (SSHA) was used to obtain scores so that the subjects within the experimental group and within the control group could be classified into high and low study-skills groups as described in the selection and characteristics of the sample section of this chapter. One purpose of the SSHA, as listed in the survey manual, is to identify students whose study habits and attitudes are different from those of students who earn high grades. The SSHA is heavily pointed in the direction of assessing motivation and attitude towards academic achievement. Correlations between single semester grade point averages and this inventory, as reported by Wrenn in Buros (1959, p. 689), range from .27 to .66 for men and .26 to .65 for women. Reliability coefficients were reported to range from .79 to .95 for different groups and different

methods. The Kuder-Richardson Formula 21 yielded a reliability coefficient of .87 when applied to the experimental and control subjects' scores on the SSHA.

The questionnaire

The final measuring instrument was a set of questions which asked the subjects about their experience and their attitude toward the remedial mathematics classes. These questions were developed by the investigator for the purpose of comparing experimental and control subjects in terms of any changes in interest and attitude toward mathematics that may have been effected by the remedial mathematics classes. In other words, one purpose of the questionnaire was to determine if experimental subjects who had used programed materials for the entire course expressed different interest and attitude toward achievement in mathematics than did control subjects who had been taught the same material by conventional procedures. Comparison of the experimental and control subjects' responses on interest and attitude are reported in the next chapter on findings. The questionnaire and a tally of the responses is included in Appendix A. The subjects in the experimental group were asked to respond to an additional set of questions concerning their reaction to learning from programed materials. These questions and a tally of the subjects' responses are included in Appendix B, and the data will be discussed in the next chapter.
Test and Texts Comparison

One of the objectives of the study was to evaluate the effectiveness of programmed materials as compared with conventional materials and procedures for teaching basic mathematics to college students. The texts determined the content taught in the experimental class and in the control class and since the same mathematics test was used as the measure of the subjects achievement in both classes, a content analysis of the texts and the mathematics test was carried out to determine the degree to which the texts and the test were related. Table 3 lists the per cent of questions in the test which sampled each content category and the per cent of pages in each text devoted to each category.

Table 3 illustrates that the first seventeen topics were treated comparably in both classes and the test sampled these topics somewhat proportionately. However, the table shows that the last four topics were not included in both texts and the test. If a topic was not taught in both classes and a test question was based on this topic, then the subjects' responses to the question were deleted from the analysis. The class time used by experimental subjects on content not covered in the control group was about four class periods. Control subjects used about seven class period studying content that was not covered in the programed tests. This means that the control group used approximately three class periods more than the
Table 3. A content analysis of the mathematics test, conventional text and programed text

<table>
<thead>
<tr>
<th>Content Category</th>
<th>Per cent of test questions</th>
<th>Per cent of pages of regular text</th>
<th>Per cent of pages of programed text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Counting and numeration</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2. Meaning of common fractions</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Meaning of decimal fractions</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4. Solving equations</td>
<td>5</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>5. Verbal problems</td>
<td>12</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>6. Addition of counting numbers</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>7. Subtraction of counting numbers</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>8. Multiplication of counting numbers</td>
<td>6</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>9. Division of counting numbers</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>10. Addition of fractions</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>11. Subtraction of fractions</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12. Multiplication of fractions</td>
<td>9</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. Division of fractions</td>
<td>10</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>14. Addition of decimal fractions</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15. Subtraction of decimal fractions</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16. Multiplication of decimal fractions</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>17. Division of decimal fractions</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Items not in all 3 sources

| 18. Rounding off digits                 | 0                           | 0                                 | 3                                    |
| 19. Money and banking                   | 0                           | 0                                 | 3                                    |
| 20. Signed numbers                      | 3                           | 4                                 | 0                                    |
| 21. Area of geometric figures           | 2                           | 4                                 | 0                                    |
experimental group on content that was not included in the analysis. There were also 31 test questions in the California Mathematics test that were based on topics not taught in either the experimental class or the control class. These 31 questions were not included as topics in Table 3 and the subjects' responses to these questions were deleted from the analysis.

Class Procedures

The experimental class

The subjects in the experimental group were instructed in basic mathematics by a set of small-step linear programmed texts. During the quarter in which the subjects used these materials, there were no class lectures or class discussions. The subjects were required to attend class Monday through Friday where they were to study in their programmed texts for the entire 50-minute period. The instructor was in the classroom during this 50 minute period and he answered questions for students on an individual basis.

The programmed texts were composed of nine chapters. The students were informed that they would have to complete the nine chapters and pass a test at the end of each chapter in order to pass the course. Chapter tests were available every Tuesday and Friday for those who had completed studying a chapter. If a student was not ready
to take a test on these days he continued to study in his text. The instructor set the passing mark for any chapter test at 70 per cent or above. If a student scored below 70 per cent on his first trial, he was to review the material in that chapter and then take an alternate form of the chapter test.

The procedure of letting subjects progress at their own rate enabled some of them to complete two chapters per week. In this way some students were able to complete the course—except for the final examination—before the end of the quarter. At the beginning of the quarter all of the experimental subjects were informed that whenever they successfully completed the nine chapter tests, they would be excused from attending the class until the end of the quarter, at which time they would have to return to take the final mathematics posttest. The result of allowing the subjects to proceed at their own rate and thereby complete the course early is discussed in the next chapter.

By the end of the fifth week the instructor saw that about 15 per cent of the students were lagging behind and that if they continued at their previous pace they would not finish the nine chapters by the end of the quarter. A minimum time schedule was suggested by the instructor to be followed by the slower students so they would complete the nine chapters in the allotted time. All of the
experimental subjects, except for two who dropped out of the university, completed the nine chapters by the end of the quarter.

The control class

Subjects in the control class were instructed by what most experimenters in programed instruction have referred to as conventional procedures. In the control class, the instructor was the central and controlling force. The textbook served for exposition, exercises, review, reference and guidance. The control subjects were exposed to a variety of activity in a repeated cycle of listening, studying examples, solving problems, and getting feedback from returned homework exercises and tests. Topics were presented each day by lecture and class discussion. Homework assignments were made each day and some class time was allowed for students to begin their assignments. The control subjects were required to attend class 50 minutes per day, 5 days per week, throughout the quarter. They were given the mathematics pretest, the posttest and other measures under the same conditions and on the same days as were the experimental subjects.

Analysis

The experimental design essentially called for obtaining two groups of college students who were required to take a non-credit course in basic mathematics and to teach
the two groups the same content by different methods. The independent variable was a type of instruction—i.e., programed instruction in the experimental group and conventional instruction in the control group. The dependent variable was achievement in basic mathematics as measured by a standardized mathematics test. The mathematics test questions were classified into two groups, those which tested fundamentals and those which tested reasoning. The mathematics pretest was given to all the subjects on the second and third days of class.

Also of concern in the investigation was the effect of mental ability and study skills on achievement when learners use programed materials. The counseling and testing service at Utah State University administered a mental ability test and a study skills test to all the subjects in the experiment. The scores on each of these measures were split at the median score. This was done so that the hypotheses pertaining to the effects of mental ability and study skills on programed learning could be tested.

At the end of the quarter in which the study was conducted, the mathematics posttest was administered to all the subjects. Correlation coefficients for mental ability scores, study skills scores, and pretest and posttest mathematics scores in fundamentals, reasoning and total test were computed. Analysis of variance was computed to compare the means on the mathematics posttest and analysis of
covariance was computed to compare the adjusted mathematics posttest means. Mental ability scores, study skills scores, and pretest mathematics scores served as covariates in the covariance analysis.

A questionnaire was given to all the subjects at the end of the investigation. The data obtained from this questionnaire made possible further comparison of the experimental and the control subjects. It also served as a means of obtaining information concerning the reactions of the subjects to the remedial mathematics classes and to programmed instruction. Chi-square tests of independence were employed to test the independence hypotheses for most of the items on the questionnaire.
Subjects whose scores are reported in the analysis

Six students in the experimental group and two students in the control group performed particularly well on the mathematics pretest. In view of their performance, the instructors recommended to the dean of general registration at Utah State University that these eight students be excused from the remedial mathematics course. This recommendation was accepted by the dean and the eight students were excused. No further measures were administered to these eight students and their scores on the mathematics pretest are not included in the analysis.

There were two students in the experimental group and two students in the control group who dropped out of the university prior to the administration of the mathematics posttest and the questionnaire. Since posttest scores and questionnaire replies were not available for these students, their scores were deleted from the analysis. The exclusion of the scores made by the four students who dropped out of the university and the exclusion of the scores made by the eight students who were excused from the remedial
mathematics course left a sample of 132 subjects—74 in the experimental group and 58 in the control group.

Class periods used by subjects

The control group met for 53 class periods. About seven of these periods were used to cover material that was not covered in the programmed text used by the subjects in the experimental group. In other words, the subjects in the control group used 46 class periods for the study of content that was tested and used in the analysis.

The experimental group was scheduled to meet for 52 class periods. About the equivalent of four class periods were used by experimental subjects to study material that was not covered in the conventional text used by subjects in the control group. The experimental subjects would have used 48 class periods for the study of content that was tested and used in the analysis; however, thirty-four experimental subjects used the opportunity that programmed materials provided for them to complete the course before the end of the quarter. Table 2 shows the number of class periods the students were excused from as a result of their being able to proceed at their own rate and thereby complete the course early.
Table 4. The number of class periods not attended by experimental subjects who completed their programs early

<table>
<thead>
<tr>
<th>Number of students</th>
<th>Days early</th>
<th>Pupil class periods not attended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>72</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>72</td>
</tr>
</tbody>
</table>

The data presented in Table 4 illustrates the advantage of individual rates of progress through use of programed materials. Certainly the fact that 192 pupil class periods were saved in one large class in one quarter should not be overlooked in the evaluation of the use of these materials. All but two of the students who completed their programs early were in the high mental ability group. It seems reasonable that students with higher mental ability scores would be able to progress through programed materials more rapidly than students with lower mental ability scores. The findings in this investigation supported this conjecture.

**Study outside of class**

Students in both the experimental group and the control group were encouraged to study outside of class. However, there were different motivational factors operating within the two groups. The subjects in the experimental group were
individually paced while the subjects in the control group were group paced. Also, the subjects in the experimental group had the additional incentive of knowing that whenever they completed the nine chapters in the programmed text they would be excused from attending class for the remainder of the quarter. At the end of the quarter all of the subjects were asked to indicate how much time they spent studying outside of class for each hour they spent in class. Table 5 shows a comparison of the responses made by experimental subjects and control subjects to this item.

Table 5. Chi-square contingency table comparing the responses made by experimental subjects and control subjects with respect to how much time they spent outside of class studying their mathematics assignments

<table>
<thead>
<tr>
<th></th>
<th>More than 2 hrs.</th>
<th>More than 1 hr.</th>
<th>Less than 1 hr.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td>11 (14.23)*</td>
<td>35 (30.74)</td>
<td>27 (29.03)</td>
<td>73</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>14 (10.77)</td>
<td>18 (23.26)</td>
<td>24 (21.97)</td>
<td>56</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25</td>
<td>53</td>
<td>51</td>
<td>129</td>
</tr>
</tbody>
</table>

\[ X^2 = 4.11 \quad \text{d.f.} = 2 \quad .10 < p < .20 \]

*The numerals in parenthesis represent the expected value for each cell on the hypothesis of independence.*
The hypothesis to test the relationship between time spent studying outside of class and type of instruction was the null hypotheses, namely, that the categorical responses made by subjects as to the amount of time they spent in study outside of class were independent of whether the subjects had conventional instruction or programed instruction. The probability value greater than .10, which is shown in Table 5, indicates that there was no significant association between time spent outside of class studying and type of instruction. The null hypothesis was accepted.

Degree of difficulty of text material

In the review of related research there were a few reports in which subjects who had used linear programs indicated that the programs were too easy and that they had become bored with the small steps and the excessive page turning associated with the programs. At the end of the 1965 fall quarter in which the study was conducted, the experimental subjects and the control subjects were asked about the degree of difficulty of the text materials that they had used in the remedial mathematics course. Table 6 shows a comparison of their responses.

The hypothesis to compare the degree of difficulty of the texts was the null hypothesis, namely, that the responses made by subjects, as to the degree of difficulty of the texts were independent of whether the subjects had used the conventional text or the programed texts. The probability
Table 6. Chi-square contingency table comparing the responses made by experimental and control subjects to an item concerning the degree of difficulty of the text material

<table>
<thead>
<tr>
<th></th>
<th>Sometimes too difficult</th>
<th>About right</th>
<th>Sometimes too easy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>(10.19)*</td>
<td>(37.91)</td>
<td>(24.90)</td>
<td>73</td>
</tr>
<tr>
<td>Control</td>
<td>(7.81)</td>
<td>(29.09)</td>
<td>(19.10)</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>67</td>
<td>44</td>
<td>129</td>
</tr>
</tbody>
</table>

\[ X^2 = 5.53 \quad \text{d.f.} = 2 \quad .05 < P < .10 \]

*The numerals in parenthesis represent the expected value for each cell on the hypothesis of independence.

value between .05 and .10 shown in Table 6 indicates no statistical association between the subjects' responses and the type of text used. The null hypothesis was accepted. Most of the subjects in both groups indicated that they thought the degree of difficulty of the text material was about right. However, there were 29 or about 39 per cent of the subjects in the experimental group and 15 or about 26 per cent of the subjects in the control group who expressed that the text material had sometimes been too easy. There were 26 more subjects who expressed that the material was sometimes too easy than there were subjects who expressed that the text material was sometimes too difficult.
Initial Differences Between The Groups on the Covariate Measures

The next step was to compare the experimental subjects with the control subjects in terms of the mean scores and standard deviations which they achieved on the three covariates—mental ability scores, study skills scores and pre-test mathematics scores.

Mental ability

The first comparison of the experimental subjects with the control subjects on the covariate measures pertained to the subjects' scores on the mental ability test. Table 7 shows a comparison of the mean scores, based on analysis of variance, and a comparison of the standard deviations, based on a variance ratio, for the subjects' scores on the mental ability test. The figures in the table are raw scores and they should not be interpreted as I.Q. or standard scores with mean of 100.

Table 7. A comparison of the means and standard deviation of the scores made by experimental subjects and control subjects on the mental ability test

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>Standard Deviation</th>
<th>d.f.</th>
<th>Variance ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>74</td>
<td>75.73</td>
<td>73</td>
<td></td>
<td>15.26</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>81.86</td>
<td>57</td>
<td></td>
<td>16.55</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>6.13</td>
<td>1/130</td>
<td>4.87*</td>
<td></td>
<td>1.29</td>
<td>57/73</td>
<td>1.18**</td>
</tr>
</tbody>
</table>

*With 1/130 d.f., F must equal or exceed 3.92 for significance at the .05 level.

**With 57/73 d.f., F must equal or exceed 1.64 for significance at the .05 level.
The difference between the mean scores made by the experimental subjects and the control subjects on the AGCT is significant beyond the .05 level and is in favor of the control group. The difference between the two groups in variability is slight and not significant at the .05 level.

The combined mean of the scores made by experimental and control subjects is 78.42 and the combined standard deviation is 15.84. When the raw scores combined mean of 78.42 is transformed into a percentile score, in terms of normative data for twelfth-grade high school students, it is at the 25th percentile. The range in raw score form is from 41 to 109. In percentile scores this range is from the 3rd percentile to the 89th percentile. These scores indicate that the subjects comprising the sample were probably not as capable, in terms of mental ability, as a random sample of twelfth-grade high school students. The range and the variance of the scores on the mental ability test indicates that the sample is distributed over a wide range of the mental ability continuum.

Study skills

The next comparison of the experimental subjects with the control subjects has to do with their scores on the study skills inventory. Table 8 shows a comparison of the mean scores, based on analysis of variance, and a comparison of the standard deviations, based on a variance ratio, for the subjects' scores on the study skills inventory.
Table 8. A comparison of the means and standard deviations of the scores made by experimental subjects and control subjects on the study skills inventory

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>Standard Deviation</th>
<th>Variance ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>74</td>
<td>22.12</td>
<td>73</td>
<td></td>
<td>9.81</td>
<td>73</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>25.45</td>
<td>57</td>
<td></td>
<td>11.69</td>
<td>57</td>
</tr>
<tr>
<td>Difference</td>
<td>3.33</td>
<td>1/130</td>
<td>3.15*</td>
<td>1.88</td>
<td>57/73</td>
<td>1.32**</td>
</tr>
</tbody>
</table>

*With 1/130 d.f., F must equal or exceed 3.92 to be significant at the .05 level.
**With 57/73 d.f., F must equal or exceed 1.64 to be significant at the .05 level.

The mean score for the subjects in the control group is greater than the mean score for the subjects in the experimental group, although the difference is not quite significant at the .05 level. The variance within the control group is likewise larger than the variance within the experimental group, but again, not quite significantly larger at the .05 level.

The combined mean score for the experimental group and the control group is 23.78. When the raw score of 23.78 is transformed into a percentile score based on normative data for college freshman (Brown, 1956), it transforms to the 20th percentile. This indicates that the subjects in the investigation, as a group, are probably below average in study habits when compared to a random sample of college freshmen. The standard deviation for the scores from which
the normative data was derived was 13.0 for men and 10.1 for women, Brown (1956). The combined standard deviation for the experimental subjects and the control subjects in the present investigation was 10.8.

Mathematics pretest

The entire California Mathematics Test, form W, was given to all of the subjects in the investigation on the second and third days of class. The responses to 36 questions, from the 140 question form W test, were deleted because they were concerned with material that was not covered in either class. The remaining 104 questions were used in the analysis. Seventy-two questions measured computation skills (fundamentals) and the other 32 questions measured problem solving ability (reasoning).

Table 9 shows a comparison of the mean scores, based on analysis of variance, and a comparison of the standard deviations, based on a variance ratio, for the subjects' scores on the mathematics pretest.

The difference between the mean scores on the questions having to do with reasoning was not significant at the .05 level, nor was the difference between the means for the total test significant at the .05 level. The difference between the mean scores on the questions having to do with fundamentals was significant at the .05 level in favor of the subjects in the control group.
Table 9. A comparison of the means and standard deviations of the scores made by experimental subjects and control subjects on the mathematics pretest

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>Standard deviation</th>
<th>d.f.</th>
<th>Variance ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fundamentals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>40.85</td>
<td>73</td>
<td>10.07</td>
<td>1.26</td>
<td>73</td>
<td>1.27**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>44.67</td>
<td>57</td>
<td>11.33</td>
<td>1.26</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>3.82</td>
<td>1/130</td>
<td>4.19*</td>
<td>.00*</td>
<td>.26</td>
<td>57/73</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reasoning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>17.11</td>
<td>73</td>
<td>3.82</td>
<td>1.26</td>
<td>73</td>
<td>1.14**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>17.14</td>
<td>57</td>
<td>4.08</td>
<td>1.26</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>.03</td>
<td>1/130</td>
<td>.00*</td>
<td>.26</td>
<td>57/73</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>57.96</td>
<td>73</td>
<td>12.34</td>
<td>1.26</td>
<td>73</td>
<td>1.37**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>61.81</td>
<td>51</td>
<td>14.42</td>
<td>1.26</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>3.85</td>
<td>1/130</td>
<td>2.73*</td>
<td>.00*</td>
<td>.26</td>
<td>57/73</td>
<td></td>
</tr>
</tbody>
</table>

*With 1/130 d.f., F must equal or exceed 3.92 for significance at .05 level.
**With 57/73 d.f., F must equal or exceed 1.64 for significance at .05 level.

It may appear to be inconsistent that the difference between the means for fundamentals was significant while the difference between the means for the total test was not, even though the difference between the means for the total test was greater than the difference between the means for fundamentals. The apparent inconsistency can be explained by the fact that the standard deviation, the basis for the
standard error of the difference between means, was greater for the total test than it was for the questions having to do with fundamentals.

Comparisons of the standard deviations reveal that there was no significant difference in variance between the experimental subjects' scores and the control subjects' scores on the mathematics pretest.

It was discussed previously that the entire 140 question California Mathematics Test was given to the subjects even though only 104 questions were used in the analysis. Since the subjects had responded to the entire 140 question test and since 1963 normative data were available for this test (California Test Bureau, 1963), mathematics grade placements were computed for the subjects. The mean-score grade placement on the mathematics pretest for the experimental subjects was 8.5 and for the control subjects, 9.0.

**Summary of Initial Differences**

The comparison of the experimental subjects with the control subjects on the three covariates—mental ability, study skills and pretest mathematics scores—revealed that the control subjects scored higher than the experimental subjects on all three of the measures. On two of the comparisons, mental ability scores and pretest fundamentals scores, the differences between the means were significantly beyond the .05 level in favor of the control subjects. The
plan to use covariance analysis to adjust for initial differences should they occur, was desirable since significant differences were found on two of the measures.

The control subjects' scores were more variable than the experimental subjects' scores on the covariate measures, although none of the differences between the standard deviations for the two groups of subjects was significant at the .05 level.

The combined scores made by the experimental subjects and the control subjects on the mental ability test yielded a mean score that transformed to the 25th percentile when it was interpreted in terms of normative data for twelfth grade high school students. The combined mean score for the experimental subjects' scores and the control subjects' scores on the study skills inventory transformed to a percentile score of 20, based on normative data for college freshmen. The grade placement for the experimental subjects, based on their mathematics pretest scores, was about grade 8.5, while the control subjects' grade placement, based on their mathematics pretest scores, was about 9.0. The 25th percentile mental ability placement and the 20th percentile study skills placement, along with the 8.5 and 9.0 mathematics grade placements indicate, as one would expect, that the sample was not as capable of academic achievement as would be a random sample of entering college freshmen.
At the end of the quarter the California Mathematics Test, form X, was given as the posttest measure. The entire set of 140 questions was administered to the subjects and following the procedure used for the pretest, form W, only 104 questions were used in the analysis of the posttest, form X. Table 10 shows a comparison of the mean scores, based on analysis of variance, and a comparison of the standard deviations, based on a variance ratio, for the subjects scores on the mathematics posttest before adjustments were made for differences between the groups on the covariates—mental ability, study skills and mathematics pretest scores.

Table 10 shows that the means for the control subjects' scores were slightly higher than the corresponding means for the experimental subjects' scores on the mathematics posttest. The difference between means was very slight, none of which was significant at the .05 level.
Table 10. A comparison of the means and standard deviations of the scores (unadjusted) made by experimental subjects and control subjects on the mathematics posttest

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>d.f.</th>
<th>F-ratio</th>
<th>Standard deviation</th>
<th>d.f.</th>
<th>Variance ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fundamentals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>53.66</td>
<td>73</td>
<td>10.36</td>
<td>73</td>
<td></td>
<td>1.02**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>54.36</td>
<td>57</td>
<td>10.48</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>0.07</td>
<td>1/130</td>
<td>.14*</td>
<td>.12</td>
<td>57/73</td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>19.49</td>
<td>73</td>
<td>4.36</td>
<td>73</td>
<td></td>
<td>1.05**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>19.36</td>
<td>57</td>
<td>4.47</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>0.13</td>
<td>1/130</td>
<td>.026*</td>
<td>.11</td>
<td>57/73</td>
<td></td>
</tr>
<tr>
<td><strong>Total Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>73.15</td>
<td>73</td>
<td>13.34</td>
<td>73</td>
<td></td>
<td>1.08**</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>73.71</td>
<td>57</td>
<td>13.88</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>0.56</td>
<td>1/130</td>
<td>.055*</td>
<td>.54</td>
<td>57/73</td>
<td></td>
</tr>
</tbody>
</table>

*With 1/130 degrees of freedom F must equal or exceed 3.92 for significance at .05 level.

**With 57/73 degrees of freedom F must equal or exceed 1.64 for significance at .05 level.

The gains in mean scores from the mathematics pretest scores to the mathematics posttest scores is worth consideration. The gains in mean scores and changes in the standard deviations, from the mathematics pretest to the mathematics posttest are presented in Table 11.
Table 11. A comparison of the means and standard deviations and changes in means and standard deviations from the mathematics pretest to the mathematics posttest (unadjusted)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fundamentals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>40.85</td>
<td>53.66</td>
<td>12.81</td>
<td>10.07</td>
<td>10.36</td>
<td>.29</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>44.67</td>
<td>54.36</td>
<td>9.69</td>
<td>11.33</td>
<td>10.48</td>
<td>.85</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>3.82</td>
<td>.70</td>
<td>3.12</td>
<td>1.26</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>17.11</td>
<td>19.49</td>
<td>2.38</td>
<td>3.82</td>
<td>4.36</td>
<td>.54</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>17.14</td>
<td>19.36</td>
<td>2.22</td>
<td>4.08</td>
<td>4.47</td>
<td>.39</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>.03</td>
<td>.13</td>
<td>.16</td>
<td>.26</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td><strong>Total Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>57.96</td>
<td>73.15</td>
<td>15.19</td>
<td>12.34</td>
<td>13.34</td>
<td>1.00</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>61.81</td>
<td>73.71</td>
<td>11.90</td>
<td>14.42</td>
<td>13.88</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>3.85</td>
<td>.56</td>
<td>3.29</td>
<td>2.08</td>
<td>.54</td>
<td></td>
</tr>
</tbody>
</table>
The experimental subjects made greater gains than the control subjects in fundamentals, reasoning and total test scores. However, one must look at the gain scores in terms of the possibility that perhaps the experimental subjects had more to learn in the course. Recall that the experimental subjects' mean scores were lower than the control subjects' mean scores on the mathematics pretest. The mathematics posttest scores will be looked at again in the next section when adjustments are made for mean score differences between the experimental subjects' scores and the control subjects' scores on the covariates.

The standard deviations shown in Table 11 reveal that the variance of the mathematics test scores within the experimental group is about the same as the variance within the control group. The standard deviations for the scores on fundamentals show a slight increase in variability from pretest to posttest for the experimental group and a slight decrease in variability for the control group. In reasoning there was a slight increase in variability for the scores of both groups. For the total test there was a point increase in variability for the experimental group and a half point decrease in variability for the control group. However, none of the changes in variability was significant at the .05 level.
Relation Among the Covariates and the Mathematics Posttest Scores

The next step in the analysis of the data was to compute correlation coefficients for the subjects' scores on the mental ability test, the study skills test and the mathematics tests. Table 12 presents a correlation matrix for the experimental subjects' scores (top numerals) and the control subjects' scores (bottom numerals).

Correlation coefficients obtained for mental ability scores, study skills scores, and mathematics pretest scores with mathematics posttest scores indicate which variables correlated sufficiently with the mathematics posttest scores so as to warrant making adjustments for differences between experimental and control subjects' mean scores.

Mental ability and posttest mathematics scores

From Table 12 it can be seen that there was a significant correlation among the mental ability scores and the mathematics posttest scores. There was also a significant difference between the means of the scores made by the experimental subjects and the control subjects on the mental ability test. Therefore, the criteria for using covariance analysis to adjust the mathematics posttest scores for differences between the experimental and the control subjects' mean scores on the mental ability test were satisfied.
Table 12. Correlation among the mental ability scores, study skills scores and pre and posttest mathematics scores for the experimental group (top numerals) and the control group (bottom numerals)

<table>
<thead>
<tr>
<th></th>
<th>Mental ability</th>
<th>Study skills</th>
<th>Pretest reas.</th>
<th>Posttest reas.</th>
<th>Pretest fund.</th>
<th>Posttest fund.</th>
<th>Pretest total</th>
<th>Posttest total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Ability</td>
<td>1.00</td>
<td>0.11</td>
<td>0.37</td>
<td>0.60</td>
<td>0.38</td>
<td>0.42</td>
<td>0.43</td>
<td>0.52</td>
</tr>
<tr>
<td>Study Skills</td>
<td>1.00</td>
<td>0.08</td>
<td>0.51</td>
<td>0.56</td>
<td>0.46</td>
<td>0.50</td>
<td>0.50</td>
<td>0.56</td>
</tr>
<tr>
<td>Pretest reas.</td>
<td>1.00</td>
<td>0.17</td>
<td>0.25</td>
<td>0.20</td>
<td>0.37</td>
<td>0.21</td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>Posttest reas.</td>
<td>1.00</td>
<td>0.14</td>
<td>0.11</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.03</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Pretest fund.</td>
<td>1.00</td>
<td>0.63</td>
<td>0.47</td>
<td>0.44</td>
<td>0.69</td>
<td>0.55</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Posttest fund.</td>
<td>1.00</td>
<td>0.76</td>
<td>0.68</td>
<td>0.81</td>
<td>0.70</td>
<td></td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Pretest total</td>
<td>1.00</td>
<td>0.65</td>
<td>0.57</td>
<td>0.72</td>
<td>0.77</td>
<td>0.77</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Posttest total</td>
<td>1.00</td>
<td>0.72</td>
<td>0.67</td>
<td>0.77</td>
<td>0.78</td>
<td>0.78</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Pretest fund.</td>
<td>1.00</td>
<td>0.70</td>
<td>0.96</td>
<td>0.76</td>
<td>0.76</td>
<td></td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Posttest fund.</td>
<td>1.00</td>
<td>0.73</td>
<td>0.98</td>
<td></td>
<td>0.78</td>
<td>0.78</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Pretest total</td>
<td>1.00</td>
<td>0.71</td>
<td>0.96</td>
<td></td>
<td></td>
<td>0.96</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Posttest total</td>
<td>1.00</td>
<td>0.74</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td>0.97</td>
<td></td>
</tr>
</tbody>
</table>
Study skills and posttest mathematics scores

There was a slight relationship among study skills and mathematics test scores for the experimental subjects, however, there was no relationship among these scores for the control subjects. Furthermore, the difference between the experimental and control subjects' mean scores on the study skills test was not significant. Therefore, the criteria for using covariance analysis to adjust the mathematics posttest scores for differences between the experimental and control subjects' mean scores on the study skills inventory were not satisfied. Covariance analysis was used, nevertheless, because of convenience in using the computer program.

The slight correlation among study skills scores and mathematics test scores for the experimental subjects who had programmed instruction and the lack of any correlation among these variables for the control subjects, does not support Borg and Cragan's (1961) findings. Recall that Borg and Cragan found a positive relation between study skills scores and achievement scores when programmed materials were not used and an inverse relation between study skills scores and achievement scores when programmed materials were used. Recall that the study skills inventory used in this investigation and in Borg and Cragan's investigation was a composite measure of study habits and attitudes and that it was heavily weighted in the direction of assessing motivation and attitude towards academic achievement.
Pretest and posttest mathematics scores

The correlation coefficients between the mathematics pretest scores and the mathematics posttest scores for both the experimental group and the control group were significant and they showed a fair degree of relationship. The difference between the means of the scores made by experimental and control subjects on the mathematics pretest was significant for the fundamentals questions but was not significant for the reasoning questions nor for the total test. With moderate correlation coefficients among mathematics pretest and posttest scores and with mean score differences that were significant for the fundamentals questions and nearly significant for the total test, covariance analysis will effect some change in the means of the mathematics posttest scores by making adjustments for differences between the means of the groups on the mathematics pretest, especially for the fundamentals questions.

Mental ability and pretest mathematics scores

Perhaps it should be noted that the adjustment for the difference between the means of the experimental and control subjects on the mathematics pretest was not independent of the adjustment for the difference between the means of the experimental and control subjects on the mental ability test. There was a significant and moderate correlation between mathematics pretest scores and mental ability scores.
The covariance analysis made an adjustment for mean score differences on the mathematics test and on the mental ability test by adjusting the posttest mean scores only once for the intersection of the two correlating covariates—mental ability scores and mathematics pretest scores.

**Mathematics Posttest Scores (Adjusted)**

The final comparison of the experimental subjects and the control subjects, in terms of their mathematics posttest scores, was a covariance analysis on the adjusted mathematics posttest mean scores. The posttest mean scores in fundamentals were adjusted for differences between experimental and control group means on the mental ability test, the study skills inventory, and the mathematics fundamentals pretest. The posttest mean scores in reasoning were adjusted for differences between experimental and control group means on the mental ability test, the study skills inventory, and the mathematics reasoning pretest. The posttest mean scores on the mathematics total test were adjusted for differences between experimental and control group means on the mental ability test, the study skills inventory, and the mathematics total pretest.

Table 13 shows the results of the covariance analysis for the mean scores of the subjects on the questions having to do with mathematics fundamentals reasoning, and the total mathematics test.
Table 13. A comparison of experimental and control subjects mean scores (adjusted) on the mathematics posttest

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>d.f.</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fundamentals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>55.18</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>52.41</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>2.77</td>
<td>1/127</td>
<td>4.65*</td>
</tr>
<tr>
<td><strong>Reasoning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>74</td>
<td>19.77</td>
<td>1/127</td>
<td>2.15*</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>18.99</td>
<td>1/127</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>.78</td>
<td>1/127</td>
<td></td>
</tr>
<tr>
<td><strong>Total Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>74</td>
<td>75.00</td>
<td>1/127</td>
<td>6.78*</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>71.34</td>
<td>1/127</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>3.66</td>
<td>1/127</td>
<td></td>
</tr>
</tbody>
</table>

*With 1/127 d.f., F must equal or exceed 3.92 for significance at the .05 level.

The findings in Table 13 indicate that there were significant mean score differences in favor of the experimental subjects over the control subjects on those questions having to do with mathematics fundamentals and on the total mathematics test. Recall that there was not a significant difference between the unadjusted mean scores on the fundamentals questions and on the total mathematics test. The different results brought about by analysis of variance and analysis of covariance illustrates the importance of employing analysis of covariance when there is a significant difference
between the means of the experimental subjects and the control subject on traits that correlate significantly with the posttest measure. In this experiment there were significant differences at the .05 level between the means of the experimental subjects' scores and the control subjects' scores in favor of the control subjects on the mental ability test and on the fundamentals part of the mathematics pretest, and the difference between the means was almost significant for the mathematics total test (See Table 9, page 75.). In addition, mental ability scores and mathematics pretest scores correlated significantly with mathematics posttest scores (See Table 12, page 831). When the differences between the unadjusted mathematics posttest means were so small (Table 10), it seemed likely that when the posttest scores were adjusted for the significant mean score differences in mental ability test scores and mathematics pretest scores, that significant mean score differences would occur in favor of the experimental group.

The results of the covariance analysis provided the necessary information for testing the hypothesis having to do with comparing the experimental subjects with the control subjects in terms of their achievement in basic mathematics.

The information needed to test the hypothesis having to do with the variability of the mathematics test scores within the experimental group and within the control groups is presented in Tables 10 and 11, pages 79 and 80. The
standard deviations used to indicate the variability of the groups are based on raw scores from the mathematics test.

Hypotheses 1.1 through 3.2 which pertain to the comparison of the experimental and control subjects' achievement and variance in mathematics are repeated here. These hypotheses are either accepted or rejected in terms of the information presented in Tables 10, 11 and 13.

1.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects having programed instruction and control subjects in a conventional class. **Rejected.** There was a significant difference beyond the .05 level in favor of the subjects in the experimental group who used programed texts.

1.2 There will be no significant difference in variance on a mathematics posttest of fundamentals between experimental subjects having programed instruction and control subjects in a conventional class. **Accepted.**

2.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects having programed instruction and control subjects in conventional class. **Accepted.**
2.2 There will be no significant difference in variance on a mathematics posttest of reasoning between experimental subjects having programed instruction and control subjects in a conventional class. Accepted.

3.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects having programed instruction and control subjects in a conventional class. Rejected. There was a significant difference beyond the .05 level in favor of the subjects in the experimental group who used programed texts.

3.2 There will be no significant difference in variance on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects having programed instruction and control subjects in a conventional class. Accepted.

Mathematics Scores: Effect of Mental Ability

To test the hypotheses pertaining to the effect of mental ability on learning mathematics from programed instruction as compared with the effect of mental ability on learning mathematics from conventional instruction, the subjects' mental ability scores were divided into high and low categories. Mathematics posttest mean scores for the four
categories, (1. experimental high, 2. experimental low, 
3. control high and 4. control low) were computed.
Analysis of variance and analysis of covariance techniques
were used to test for the significance of the difference
among all four means. The F-ratios determined if signifi­
cant differences existed among the means and the t-tests
determined which pairs of means were significantly different.
Means, mean differences, t-ratios and standard deviation are
shown in Tables 14, 15 and 16. The degrees of freedom for
the analysis of variance were 3/128 and for the covariance
analysis the degrees of freedom were 3/126. For 3/128 and 
3/126 degrees of freedom an F-ratio of 3.92 or beyond is
required to obtain significance at the .05 level. The
degrees of freedom for the t-tests were from 56 to 72. For
degrees of freedom in this range, a t-ratio of 2.00 or beyond
is required to obtain significance at the .05 level.

Fundamentals

The first comparison of the posttest mathematics mean
scores of subjects in the different mental ability cate­
gories was for the mathematics fundamentals questions. An
F-ratio of 5.13, which is significant beyond the .05 level,
was obtained for the comparison of the four means before
they were adjusted for differences in study skills and
mathematics fundamentals pretest scores. The unadjusted
means, t-ratios and standard deviations are shown in the
first part of Table 14. The adjusted means and the t-ratios
Table 14. Comparison of the mean scores made by subjects in the high low mental ability categories on the mathematics posttest fundamentals questions

Fundamentals (before adjustment)

<table>
<thead>
<tr>
<th>Mental Ability</th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>Stand. dev.</td>
<td>N</td>
<td>Mean</td>
<td>Stand. dev.</td>
<td>Mean dif.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>34</td>
<td>58.03</td>
<td>7.09</td>
<td>32</td>
<td>56.78</td>
<td>9.33</td>
<td>1.25</td>
<td>$t_{64} = .51^*$</td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
<td>50.33</td>
<td>8.61</td>
<td>26</td>
<td>51.35</td>
<td>10.88</td>
<td>1.02</td>
<td>$t_{64} = .41^*$</td>
</tr>
<tr>
<td>Mean Diff.</td>
<td></td>
<td></td>
<td>7.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$t_{72} = 3.38^*$</td>
</tr>
</tbody>
</table>

Fundamentals (after adjustment)

<table>
<thead>
<tr>
<th>Mental Ability</th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td></td>
<td>N</td>
<td>Mean</td>
<td></td>
<td>Mean dif.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>34</td>
<td>56.32</td>
<td></td>
<td>32</td>
<td>53.37</td>
<td>2.95</td>
<td>$t_{64} = 1.67^*$</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
<td>53.87</td>
<td>2.45</td>
<td>26</td>
<td>51.94</td>
<td>1.93</td>
<td>$t_{64} = 1.06^*$</td>
<td></td>
</tr>
<tr>
<td>Mean Diff.</td>
<td></td>
<td></td>
<td>$t_{72} = 1.46^*$</td>
<td></td>
<td></td>
<td>$t_{56} = .75^*$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*With 55 to 75 d.f., $t$ must equal or exceed 2.00 for significance at .05 level.

are shown in the second part of Table 14. An F-ratio of 1.86, which is not significant at the .05 level, was obtained for the adjusted mean scores.
The t-tests presented in the first part of Table 14 show that the difference between the unadjusted means of the high and low mental ability groups within the experimental group and within the control group were significant and in favor of the high mental ability group for the mathematics posttest fundamentals questions. These results support previous findings presented in Table 7, of significant positive correlations between mental ability scores and mathematics fundamentals scores. None of the differences between corresponding pairs of means for the comparison of the experimental group with the control group was significant.

The standard deviations presented in Table 14 reveal that the variance within the control high and low mental ability groups was slightly greater than the variance within the corresponding experimental high and low mental ability groups. The variance within the low mental ability groups was slightly higher than the variance within the corresponding high mental ability groups. However, none of the differences in standard deviations was significant.

The t-tests in the second part of Table 14 show that when the adjustments for mean score differences between the high and low mental ability groups on the study skills inventory and on the mathematics fundamentals pretest were made, none of the differences between the posttest mean scores on the mathematics questions was significant.

The data presented in Table 14 can be used to test Hypotheses 4.1 through 4.4 which pertain to the effect of
mental ability on achievement in mathematics fundamentals through programmed instruction and through conventional instruction. These hypotheses are repeated here and they are either accepted or rejected in terms of adjusted means presented in the second part of Table 14.

4.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a mental ability test and experimental subjects who scored below the median on the mental ability test. **Accepted.**

4.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test. **Accepted.**

4.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test. **Accepted.**

4.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored below
the median on a mental ability test and control subjects who scored below the median on the mental ability test. **Accepted.**

**Reasoning**

The second comparison of the posttest mathematics mean scores of subjects in the different mental ability categories was for the mathematics reasoning questions. An F-ratio of 12.65, which is significant beyond the .05 level, was obtained for the comparison of the four means before they were adjusted for differences in study skills and mathematics reasoning pre-test scores. The unadjusted means, t-ratios and standard deviations are shown in the first part of Table 15. An F-ratio of 5.24, which is significant beyond the .05 level, was obtained for the adjusted mean scores. The adjusted means and the t-ratios are shown in the second part of Table 15.

The t-tests presented in Table 15 show that the difference between the mean scores on the mathematics posttest reasoning questions was significant and favored the high mental ability group over the low mental ability group for each comparison. The mean score differences in favor of the high mental ability groups occurred before and after the means were adjusted. These results support previous findings, presented in Table 7, of significant positive correlations among mental ability scores and mathematics reasoning scores. None of the differences between corresponding pairs of means for the comparison of the experimental group with the control group was significant.
Table 15. Comparison of the mean scores made by subjects in the high and the low mental ability categories on the mathematics posttest reasoning questions

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental ability</td>
<td>N</td>
<td>Mean</td>
<td>Stand dev.</td>
<td>N</td>
</tr>
<tr>
<td>High</td>
<td>34</td>
<td>21.97</td>
<td>2.88</td>
<td>32</td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
<td>17.60</td>
<td>4.13</td>
<td>26</td>
</tr>
<tr>
<td>Mean dif.</td>
<td></td>
<td>4.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$t_{72} = 4.80^*$  
$t_{56} = 3.86^*$

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental ability</td>
<td>N</td>
<td>Mean</td>
<td>Mean dif.</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>34</td>
<td>21.00</td>
<td>2.63</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
<td>18.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$t_{72} = 3.68^*$  
$t_{56} = 2.19^*$

*With 55 to 75 d.f., t must equal or exceed 2.00 for significance at .05 level.

The standard deviations for the unadjusted scores on mathematics posttest reasoning questions show the control high and low mental ability groups had slightly more variance than the corresponding experimental high and low mental ability groups. The variance within the low mental ability
groups was slightly greater than the variance within the high mental ability groups. However, none of the differences in standard deviations were significant.

The data presented in Table 15 can be used to test Hypotheses 5.1 through 5.4 which pertain to the effect of mental ability on achievement in mathematics reasoning through programmed instruction and through conventional instruction. These hypotheses are repeated here and they are either accepted or rejected in terms of the adjusted means presented in the second part of Table 15.

5.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on the mental ability test and experimental subjects who scored below the median on the mental ability test. Rejected. There was a significant difference beyond the .05 level in favor of the high mental ability group.

5.2 There will be no significant difference in mean scores on a mathematics posttest of reasoning between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test. Rejected. There was a significant difference beyond the .05 level in favor of the high mental ability group.
5.3 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test. Accepted.

5.4 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored below the median on a mental ability test and control subjects who scored below the median on the mental ability test. Accepted.

**Total test**

The final comparison of the posttest mathematics mean scores of subjects in the different mental ability categories was for the total mathematics test. An F-ratio of 8.38, which is significant beyond the .05 level, was obtained for the comparison of the four means before they were adjusted for differences in study skills and mathematics pretest scores. The unadjusted means, t-ratios and standard deviations are shown in the first part of Table 16. An F-ratio of 4.12, which is significant at the .05 level, was obtained for the adjusted mean scores. The adjusted means and the t-ratios are shown in the second part of Table 16.
Table 16. Comparison of the means and standard deviations of the scores made by high and low mental groups on the total mathematics posttest

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mental ability</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>34</td>
<td>80.00</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>40</td>
<td>67.93</td>
</tr>
<tr>
<td>Mean dif.</td>
<td></td>
<td></td>
<td>12.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Test (before adjustment)

Total Test (after adjustment)

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th></th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mental ability</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>34</td>
<td>76.92</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>40</td>
<td>72.84</td>
</tr>
<tr>
<td>Mean dif.</td>
<td></td>
<td>4.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*With 55 to 75 d.f., t must equal or exceed 2.00 for significant at .05 level.

The t-tests presented in the first part of Table 16 show that the difference between the unadjusted means of the high and low mental ability groups within the experimental group and within the control group was significant and in favor of the high mental ability group for the total mathematics test.
scores. None of the differences between the unadjusted means of the corresponding high and low mental ability sections in the comparisons of the experimental group with the control group were significant.

The standard deviations for the unadjusted mathematics total posttest scores reveal that the variance within the high mental ability control group was significantly greater than the variance within the high mental ability experimental group. The variance within the low mental ability experimental group was significantly greater than the variance within the high mental ability experimental group. The variance within the low mental ability control group was also greater than the variance within the high mental ability control group, but the difference was not quite significant.

The t-tests in the second part of Table 16 indicate that when the adjustments for mean score differences between the groups on the study skills inventory and on the mathematics pretest were made, the difference between the means of the high and low mental ability groups within the experimental group was significant but within the control group the difference was not significant. There was also a significant difference between the means in favor of the high mental ability experimental group over the high mental ability control group on the adjusted mean scores.

The data presented in Table 16 can be used to test Hypotheses 6.1 through 6.4 which pertain to the effect of
mental ability on achievement in mathematics fundamentals and reasoning through programmed instruction and through conventional instruction. The hypotheses are repeated here and they are either accepted or rejected in terms of the adjusted means presented in the second part of Table 16.

6.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored above the median on a mental ability test and experimental subjects who scored below the median on the mental ability test. **Rejected.** There was a significant difference beyond the .05 level in favor of the high mental ability group.

6.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between control subjects who scored above the median on a mental ability test and control subjects who scored below the median on the mental ability test. **Accepted.**

6.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored above the median on a mental ability test and control subjects who scored above the median on the mental ability test. **Rejected.**
There was a significant difference beyond the .05 level in favor of the experimental high mental ability group.

6.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored below the median on a mental ability test and control subjects who scored below the median on the mental ability test. Accepted.

Mathematics Scores--Effect of Study Habits

To test the hypotheses pertaining to the effect of study habits on learning mathematics from programmed instruction as compared with the effect of study habits on learning mathematics from conventional instruction, the subjects' study skills scores were divided into high and low categories. Mathematics posttest mean scores for the four categories (1. experimental, 2. experimental low, 3. control high and 4. control low) were computed. Analysis of variance and analysis of covariance techniques were used to test for the significance of the difference among all four means.

The correlation coefficients in Table 12 illustrated that there was no correlation between study skills scores and mathematics test scores for the subjects learning from conventional procedures and that there was a very mild but significant correlation between study skills scores and
mathematics test scores for the subjects learning from programmed instruction. Therefore, the effect of dividing the subjects' scores into high and low study skills categories will produce more meaningful results for the analysis of the experimental groups' scores than it will for the analysis of the control groups' scores. In other words, since there was a mild correlation between study skills scores and mathematics test scores for the subjects in the experimental group, a mean score difference in mathematics test scores occurring between the subjects' scores in the high and the low study skills categories may be partially attributed to differences in study skills. On the other hand, since there was no correlation between study skills and mathematics test scores for the subjects in the control group, a mean score difference in mathematics test scores occurring between the subjects' scores in the control high and low study skills categories will probably result from factors other than differences in study skills.

The F-ratios from the analysis of variance and the analysis of covariance determined if significant differences existed among the four means and the t-tests determined which pairs of means were significantly different. Means, mean differences, t-ratios and standard deviations are shown in Tables 17, 18 and 19. The degrees of freedom for the analysis of variance were 3/128 and for the covariance analysis the degrees of freedom were 3/126. With 3/128 and 3/126 degrees
of freedom an F-ratio of 3.92 or beyond is required to obtain
significance at the .05 level. The degrees of freedom for
the t-tests range from 56 to 72. With degrees of freedom in
the 56 to 72 range, a t-ratio of 2.00 or beyond is required
to obtain significance at the .05 level.

Fundamentals
The first comparison of the posttest mathematics mean
scores of subjects in the different study skills categories
was for the mathematics fundamentals questions. An F-ratio
of 1.56, which is not significant at the .05 level, was
obtained for the comparison of the four means before they
were adjusted for differences in mental ability and mathe­
matics fundamentals pretest scores. The unadjusted means
and standard deviations are shown in the first part of Table
17. An F-ratio of 1.97, which is not significant at the .05
level, was obtained for the adjusted mean scores. The adjusted
means are shown in the second part of Table 17. Neither F­
ratio was significant at the .05 level and consequently, no
t-ratios were computed to test for significant differences
pairs of means.

The insignificant mean score difference which occurred
between the high and low study skills groups was in favor of
the high study skills group for each comparison. There was
a slight insignificant mean score difference in favor of the
experimental high study skills group over the control high
study skills group. The control low study skills group mean
Table 17. Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics posttest fundamentals questions

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>N</th>
<th>Mean</th>
<th>Stand. dev.</th>
<th>N</th>
<th>Mean</th>
<th>Stand. dev.</th>
<th>Mean def.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>35</td>
<td>56.18</td>
<td>9.35</td>
<td>31</td>
<td>55.48</td>
<td>9.75</td>
<td>.70</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>51.52</td>
<td>9.32</td>
<td>27</td>
<td>53.04</td>
<td>10.91</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Fundamentals (after adjustments)

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>N</th>
<th>Mean</th>
<th>N</th>
<th>Mean</th>
<th>Mean diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>35</td>
<td>56.16</td>
<td>31</td>
<td>53.35</td>
<td>2.81</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>54.04</td>
<td>27</td>
<td>51.78</td>
<td>3.26</td>
</tr>
</tbody>
</table>

was slightly higher than the experimental low study skills group mean before adjustments. After adjustments, the non-significant mean score difference was in favor of the experiment group.

The standard deviations reported in Table 17 are practically the same for each study skills group. The small difference between standard deviations indicates there was very little difference in variance between the groups.
The data presented in Table 17 can be used to test Hypotheses 7.1 through 7.4 which pertain to the effect of study skills on achievement in mathematics fundamentals through programed instruction and through conventional instruction. These hypotheses are repeated here and they are all accepted since neither F-ratio was significant.

7.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits. Accepted.

7.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between control subjects who scored above the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. Accepted.

7.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals between experimental subjects who scored above the median on a survey of study habits and control subjects who scored above the median on the survey of study habits. Accepted.

7.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals
between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. Accepted.

Reasoning

The second comparison of the posttest mathematics mean scores of subjects in the different study skills categories was for the mathematics reasoning questions. An F-ratio of 1.82, which is not significant at the .05 level, was obtained for the comparison of the four means before they were adjusted for differences in mental ability and mathematics reasoning pretest scores. The unadjusted means and standard deviations are shown in the first part of Table 18. An F-ratio of 2.08, which is not significant at the .05 level, was obtained for the adjusted mean scores. The adjusted means are shown in the second part of Table 18. Neither F-ratio was significant at the .05 level and consequently, no t-ratios were computed to test pairs of means for significant differences.

The insignificant mean score difference which occurred between the experimental high study skills group and the experimental low study skills group was in favor of the high study skills group in each comparison. However, within the control group, the mean score difference was in favor of the low study skills group over the high study skills group. This latter result agrees with the finding presented in Table 12, of a -.11 correlation coefficient for study skills
Table 18. Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics posttest reasoning questions

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>High</td>
<td>35</td>
<td>20.65</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>18.50</td>
</tr>
</tbody>
</table>

Reasoning (after adjustments)

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>High</td>
<td>35</td>
<td>20.48</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>19.13</td>
</tr>
</tbody>
</table>

scores and posttest reasoning scores. There was a small insignificant mean score difference in favor of the experimental high study skills group over the control high study skills group in each comparison. However, the mean for the control low study skills group was slightly higher than the mean for the experimental low study skills group in each comparison.
The standard deviations reported in Table 18 are practically the same for each study skills group. The small difference between standard deviations indicates small differences in variance between the groups.

The data presented in Table 18 can be used to test Hypotheses 8.1 through 8.4 which pertain to the effect of study skills on achievement in mathematics reasoning through programmed instruction and through conventional instruction. These hypotheses are repeated here and they are all accepted since neither F-ratio was significant.

8.1 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits. Accepted.

8.2 There will be no significant difference in mean scores on a mathematics posttest of reasoning between control subjects who scored above the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. Accepted.

8.3 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored above the
median on a survey of study habits and control subjects who scored above the median on the survey of study habits. Accepted.

8.4 There will be no significant difference in mean scores on a mathematics posttest of reasoning between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. Accepted.

Total test

The final comparison of the posttest mathematics mean scores of subjects in the different study skills categories was for the total mathematics test. An F-ratio of 1.63, which is not significant at the .05 level, was obtained for the comparison of the four means before they were adjusted for differences in mental ability and mathematics pretest scores. The unadjusted means and standard deviations are shown in the first part of Table 19. An F-ratio of 3.03 was obtained for the adjusted mean scores. The adjusted means are shown in the second part of Table 19. Neither F-ratio was significant and consequently, no t-ratios were computed to test pairs of means for significant differences.

The insignificant mean score differences which occurred between the high and low study skills groups were in favor of the high study skills group for each comparison. There was a small insignificant mean score difference in favor of the
Table 19. Comparison of the mean scores made by subjects in the high and low study skills categories on the mathematics total test

### Total Test (before adjustments)

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>Experimental</th>
<th>Control</th>
<th>Mean</th>
<th>Stand. dev.</th>
<th>Mean</th>
<th>Stand. dev.</th>
<th>Mean dif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>35</td>
<td>31</td>
<td>76.82</td>
<td>11.60</td>
<td>74.32</td>
<td>13.17</td>
<td>2.50</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>27</td>
<td>70.03</td>
<td>14.17</td>
<td>73.00</td>
<td>14.16</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.79</td>
<td></td>
<td>1.32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Total Test (after adjustments)

<table>
<thead>
<tr>
<th>Study Skills</th>
<th>Experimental</th>
<th>Control</th>
<th>Mean</th>
<th>Mean dif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>35</td>
<td>31</td>
<td>76.56</td>
<td>4.36</td>
</tr>
<tr>
<td>Low</td>
<td>39</td>
<td>27</td>
<td>73.34</td>
<td>2.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.22</td>
<td></td>
</tr>
</tbody>
</table>

The experimental high study skills group over the control high study skills group in each comparison. The control low study skills group mean was slightly greater than the experimental low study skills group mean before adjustments. After adjustments, the mean score difference was in favor of the experimental low study skills group.

The standard deviations reported in Table 19 are practically the same for each study skills group. The small difference between standard deviations indicates small differences in variance between the groups.
The data presented in Table 19 can be used to test Hypotheses 9.1 through 9.4 which pertain to the effect of study skills on achievement in mathematics through programed instruction and through conventional instruction. These hypotheses are repeated here and they are all accepted since neither F-ratio was significant.

9.1 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored above the median on a survey of study habits and experimental subjects who scored below the median on the survey of study habits. **Accepted.**

9.2 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between control subjects who scored above the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. **Accepted.**

9.3 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored above the median on a survey of study habits and control subjects who scored above the median on the survey of study habits. **Accepted.**
9.4 There will be no significant difference in mean scores on a mathematics posttest of fundamentals and reasoning (total test) between experimental subjects who scored below the median on a survey of study habits and control subjects who scored below the median on the survey of study habits. Accepted.

Questionnaire on Interest and Attitude

Subjects' interest in mathematics

In Chapter IV we discussed the questionnaire which was incorporated to obtain additional information from the subjects. Three items on the questionnaire pertained to the subjects' interest in mathematics. The first one, Item Number Five on the questionnaire in Appendix A, asked each subject to select from the five choices (1. very high, 2. high, 3. average, 4. low and 5. very low) the one that best described his interest in mathematics before he took the remedial mathematics course. Only one experimental subject and one control subject chose the very high category. These two responses were included in the high category for the purpose of comparing the experimental and control subjects' responses through a chi-square analysis which is shown in Table 20. The hypothesis to be tested is the null hypothesis, namely, that the subjects' responses to the different categories are independent of whether the subjects were in the experimental group or the control group.
Table 20. Chi-square contingency table comparing experimental and control subjects in terms of interest in mathematics prior to taking the remedial mathematics course

<table>
<thead>
<tr>
<th>Group</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
<th>Very Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>(7.36)*</td>
<td>(25.47)</td>
<td>(27.73)</td>
<td>(12.45)</td>
<td>73</td>
</tr>
<tr>
<td>Control</td>
<td>(5.64)</td>
<td>(19.53)</td>
<td>(21.27)</td>
<td>(9.55)</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>45</td>
<td>49</td>
<td>22</td>
<td>129</td>
</tr>
</tbody>
</table>

\[ X^2 = 1.12 \quad \text{d.f.} = 3 \quad .70 < p < .80 \]

*The numerals in parentheses represent the expected value on the hypothesis of independence for each cell.

The probability value which lies between .70 and .80, shown in Table 20, indicated that the chi-square value was not significant and therefore the null hypothesis was accepted. The observed results are close to those to be expected on the hypothesis of independence and there is no evidence of any association between the responses and whether the subjects were in the experimental group or the control group.

The second item which pertained to the subjects interest in mathematics was Item Number Six on the questionnaire in Appendix A. For item six, each subject was asked to select one of the five choices (1. increased considerably, 2. increased some, 3. remained about the same, 4. decreased some and 5. decreased considerably) which he thought best represented the effect the course had on his interest in mathematics.
None of the subjects checked the decreased considerably category and only two subjects, one in the experimental group and one in the control group, checked the decreased some category. These two responses were included in the remained about the same category for the purpose of comparing the experimental and control subjects' responses through a chi-square analysis which is shown in Table 21. The hypotheses to be tested is the null hypothesis, namely, that the subjects' responses to the different categories are independent of whether the subjects had programmed instruction or conventional instruction.

The probability value which lies between .50 and .70, shown in Table 21, indicated that the chi-square value was not significant and therefore the null hypothesis was accepted. The observed results were close to those to be expected on the hypothesis of independence and there was no evidence of any association between the responses and the type of instruction which the subjects had received.

In the conventionally taught group, 30 per cent of the subjects indicated that their interest in mathematics had increased considerably, 48 per cent indicated their interest in mathematics had increased some and 22 per cent indicated their interest in mathematics had remained about the same as a result of the remedial mathematics course. In the programmed learning group, 27 per cent of the subjects indicated that their interest in mathematics had increased considerably, 43 per cent indicated their interest in mathematics had
Table 21. Chi-square contingency table comparing experimental and control subjects on the effect of the remedial mathematics class on their interest in mathematics.

<table>
<thead>
<tr>
<th></th>
<th>Increased Considerably</th>
<th>Increased some</th>
<th>Remained the same</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td>(20.94)*</td>
<td>(32.82)</td>
<td>(19.24)</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>31</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>(16.06)</td>
<td>(25.18)</td>
<td>(14.76)</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>27</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>37</td>
<td>58</td>
<td>34</td>
<td>129</td>
</tr>
</tbody>
</table>

\[ X^2 = 1.24 \quad \text{d.f.} = 2 \quad .50 < p < .70 \]

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

increased some and 30 per cent indicated their interest in mathematics had remained about the same as a result of the remedial mathematics course.

The last item pertaining to interest, Item Number Seven on the questionnaire in Appendix A, asked each subject to rate the remedial mathematics course in terms of interest with other mathematics courses he had taken. There were five choices (1. very high, 2. high, 3. average, 4. low and 5. very low) from which each subject was asked to check the one that best described his rating of the remedial mathematics course. Three subjects in the experimental group and eight subjects in the control group checked the category, very high. Two subjects in the experimental group and two subjects in the
control group checked the very low category. Since the number of responses to the very high category and to the very low category were so few, these responses were included in the high category and low category respectively for the purpose of comparing the experimental and control subjects' responses through a chi-square analysis which is shown in Table 22. The hypothesis to be tested is the null hypothesis, namely, that subjects' responses to the different categories are independent of whether the subjects were in the experimental group or the control group.

The probability value between .01 and .05, shown in Table 22 indicates the probability of exceeding the obtained chi-square value of 7.25 is too unlikely an occurrence to be accounted for solely by sampling fluctuations. The independence hypothesis was therefore rejected. The most noticeable difference between the tabulated results and those to be expected on the hypotheses of independence occurred within the high category. The number of experimental subjects who checked the high category was approximately seven below the independence value whereas the number of control subjects who checked the high category was approximately seven above the independence value. The control subjects tended to rate the interest of the conventional remedial mathematics course, when compared with their interest in other mathematics courses they had taken, higher than the experimental subjects
Table 22. Chi-square contingency table comparing experimental and control subjects on how they rated the interest of the remedial mathematics class with other mathematics courses they had taken

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Average</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>(29.43)*</td>
<td>(31.69)</td>
<td>(11.88)</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>37</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>(22.57)</td>
<td>(24.31)</td>
<td>(9.12)</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>19</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>56</td>
<td>21</td>
<td>129</td>
</tr>
</tbody>
</table>

$X^2 = 7.25$  
d.f. = 2  
$.01 < p < .05$

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

rated the interest of the programed remedial mathematics course, when compared with their interest in other mathematics courses they had taken.

Subjects' attitudes toward their achievement in the remedial mathematics course

Three items on the questionnaire pertained to the subjects' attitudes toward the achievement in the remedial mathematics course. The experimental and control subjects were compared in terms of their responses to these three items.

The first item, Item Number 8 on the questionnaire in Appendix A, asked each student to choose from the five choices (1. very good, 2. good, 3. average, 4. poor and 5. very poor) the one choice that best described what he thought his knowledge of basic mathematics had been before he took the
remedial mathematics course. Only four subjects, three in the experimental group and one in the control group checked the category very good. These four responses were included in the good category for the purpose of a chi-square analysis which is shown in Table 23. The hypotheses to be tested is the null hypothesis, namely, that the responses to the different categories are independent of whether the subjects were in the experimental group or the control group.

Table 23. Chi-square contingency table comparing experimental and control subjects on what they thought their knowledge of basic mathematics was prior to taking the remedial mathematics course.

<table>
<thead>
<tr>
<th></th>
<th>Good (13.02)*</th>
<th>Average (23.77)</th>
<th>Poor (28.29)</th>
<th>Very Poor (7.92)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>14</td>
<td>22</td>
<td>28</td>
<td>9</td>
<td>73</td>
</tr>
<tr>
<td>Control</td>
<td>(9.98)</td>
<td>(18.23)</td>
<td>(21.71)</td>
<td>(6.08)</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>42</td>
<td>50</td>
<td>14</td>
<td>129</td>
</tr>
</tbody>
</table>

\[X^2 = .81\] \hspace{1cm} \text{d.f. = 3} \hspace{1cm} .90 < P < 1.00

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

The probability value which lies between .90 and 1.00 indicates that the chi-square value is not significant and therefore the null hypothesis is accepted. The observed results are very close to those to be expected on the hypothesis of independence and there is no evidence of any association between the responses and whether the subjects were in the experimental group or the control group.
The second item pertaining to the subjects' responses with regards to their achievement in the remedial mathematics course was Item Number Nine on the questionnaire in Appendix A. For this item each subject was asked to choose from the five choices (1. very much, 2. much, 3. some, 4. little and 5. none) the one that best described how much he thought his knowledge of basic mathematics had increased as a result of his experience in the remedial mathematics course. Only two subjects, both of which were in the experimental group, checked the category none. These two responses were included in the little category for the purpose of a chi-square analysis which is shown in Table 24. The hypotheses to be tested is the null hypothesis, namely, that the responses to the different categories are independent of whether the subjects had programmed instruction or conventional instruction.

The probability value which lies between .10 and .20 indicates that the chi-square value is not quite significant and therefore the null hypothesis is accepted. The observed results are close to those to be expected on the hypothesis of independence and there is no evidence of an association between the responses and the type of instruction.

The last item pertaining to the subjects' responses with regards to their achievement in the remedial mathematics course was Item Number 10 on the questionnaire in Appendix A. For this item, each subject was asked to rate the remedial mathematics course in terms of how much he thought he had
Table 24. Chi-square contingency table comparing experimental and control subjects on their responses to a question concerning the increase in knowledge of basic mathematics they thought they had obtained as a result of taking the remedial mathematics course

<table>
<thead>
<tr>
<th>Very Much</th>
<th>Much</th>
<th>Some</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(15.23)*</td>
<td>(26.03)</td>
<td>(31.69)</td>
<td>73</td>
</tr>
<tr>
<td>Experimental</td>
<td>19</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>(11.72)</td>
<td>(19.97)</td>
<td>(24.31)</td>
<td>56</td>
</tr>
<tr>
<td>Control</td>
<td>8</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>46</td>
<td>56</td>
</tr>
<tr>
<td>X² = 4.45</td>
<td>d.f. = 2</td>
<td>.10 &lt; P &lt; .20</td>
<td></td>
</tr>
</tbody>
</table>

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

learned in this course as compared with how much he thought he had learned in other mathematics courses he had taken. Each subject was asked to choose from the five choices (1. very high, 2. high, 3. average, 4. low and 5. very low) the one that best described his comparative rating of the course. Two subjects in the experimental group and no students in the control group chose the very low category. The two responses to the very low category were included in the low category for the purpose of a chi-square analysis which is shown in Table 25. The hypothesis to be tested is the null hypothesis, namely, that the responses to the different categories are independent of whether the subjects had programmed instruction or conventional instruction.
Table 25. Chi-square contingency table comparing experimental and control subjects' responses to an item asking them to rate the amount of mathematics they thought they had learned in the remedial mathematics course with the amount of mathematics they thought they had learned in other mathematics classes

<table>
<thead>
<tr>
<th></th>
<th>Very High</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td>(7.92)*</td>
<td>(26.60)</td>
<td>(27.73)</td>
<td>(10.75)</td>
<td>73</td>
</tr>
<tr>
<td>Experimental</td>
<td>7</td>
<td>21</td>
<td>34</td>
<td>11</td>
<td>73</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>(6.08)</td>
<td>(20.40)</td>
<td>(21.27)</td>
<td>(8.25)</td>
<td>56</td>
</tr>
<tr>
<td>Control</td>
<td>7</td>
<td>26</td>
<td>15</td>
<td>8</td>
<td>56</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>14</td>
<td>47</td>
<td>49</td>
<td>19</td>
<td>129</td>
</tr>
</tbody>
</table>

\[ X^2 = 4.45 \]
\[ d.f. = 3 \]
\[ .20 < p < .30 \]

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

The probability value between .20 and .30 shown in Table 23, indicates that the chi-square value is not significant and therefore the null hypothesis was accepted. The observed results are close to those to be expected on the hypothesis of independence and there is no evidence of any association between the responses and the type of remedial mathematics instruction the subjects had received.

Subjects' attitudes toward being required to take the remedial mathematics course

The next comparison of the experimental and control subjects has to do with their responses to Item Number 14 on the questionnaire. For Item Number 14, each subject was asked to select from the four categories (1. very pleased
the university provided this course for me, 2. pleased the university provided this course for me, 3. sorry the university required me to take this course, 4. very sorry the university required me to take this course) the one which best described his attitude toward his remedial mathematics requirement. Two experimental subjects and no control subjects selected the very sorry the university required me to take this course category. These two responses were included in the sorry the university required me to take this course category for the purpose of comparing the experimental and the control subjects' responses through a chi-square analysis which is shown in Table 26. The hypothesis to be tested is the null hypotheses, namely, that the responses to the different categories are independent of whether the subjects had programed instruction or conventional instruction.

The probability value which lies between .80 and .90 indicates that the chi-square value is not significant and therefore the null hypothesis was accepted. The observed results are very close to those expected on the hypothesis of independence and there is no evidence of any association between the responses and whether the subjects had programed instruction or conventional instruction. About 85 per cent of the subjects indicated that they were at least pleased the university had provided the remedial mathematics course for them. Only 15 per cent of the subjects indicated they were sorry the university had required them to take the remedial mathematics course.
Table 26. Chi-square contingency table comparing experimental and control subjects' responses with regards to their attitudes toward the remedial mathematics course requirement

<table>
<thead>
<tr>
<th>Group</th>
<th>Very pleased the university provided this course for me</th>
<th>Pleased the university provided this course for me</th>
<th>Sorry I was required to take this course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>21</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Control</td>
<td>(22.07)*</td>
<td>(40.17)</td>
<td>(10.75)</td>
</tr>
<tr>
<td>Control</td>
<td>18</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>71</td>
<td>19</td>
</tr>
</tbody>
</table>

\[ X^2 = .31 \quad \text{d.f.} = 2 \quad .80 < P < .90 \]

*The numerals in parentheses represent the expected value for each cell on the hypothesis of independence.

Subjects' comments about the course

The subjects in the experimental group and in the control group were asked to comment on what they thought were the most favorable characteristics of the remedial mathematics course and on what they thought were the least favorable characteristics of the course.

In the control group, the favorable characteristic listed most frequently had to do with the subjects' appreciation that the class pace was slow enough to enable them to learn subject matter which they had missed or not understood in their high school mathematics classes. However, the slow group pace also drew the most number of comments with regards to
the least favorable characteristic of the course. A number of students indicated that the course would have been more beneficial for them if the group pace had been faster and if they could have covered more subject matter. The instructors of the remedial mathematics classes also felt that the pace was about right for some of the subjects and too slow for others. The fact that this problem existed was used by the instructors to support their recommendation that future remedial mathematics students be given additional testing for placement and a beginning algebra course be made available for those students who show competence in basic mathematics. Other comments which were favorable to the conventional remedial mathematics class had to do with appreciation for the opportunity to review ideas which had been forgotten and appreciation for the patience and understanding that the instructor had exhibited throughout the course.

By far the greatest number of favorable comments expressed by the subjects in the experimental group had to do with the opportunity that programmed materials had given each student to go at his own rate. The second most frequent comment favorable toward the experimental remedial course had to do with the opportunity programmed materials had provided for each student to be on his own to learn the material. Other favorable comments directly related to the use of the programmed texts had to do with the small-step logical-sequencing of ideas in the texts and the immediate availability of the answers for reward and confirmation.
The characteristics of the remedial mathematics course which experimental subjects listed most frequently as disliked most were: the text was too easy, the course was boring, there was too much repetition in the text, there was no college credit given for the course, and there was no class discussion. One interesting observation, from a review of the subjects' comments, was that the subjects who listed individual rates of learning as the most favorable characteristic of the course also listed no class discussion as the least favorable characteristic of the course. It seems that the students want individual pacing and at the same time they want class discussions which tend to be grouped paced in a mathematics class.

**Questionnaire on Programed Instruction**

At the completion of the course, a set of questions pertaining to some of the characteristics of programed instruction was given to all of the subjects in the experimental group. A copy of these questions and a tally of the subjects' responses to the questions are included in Appendix B. A discussion of the subjects' responses to the questions follows.

**Small steps and logical sequencing**

One characteristic of a linear program is that it presents each idea or concept through a sequence of small steps. Item Number One on the questionnaire asked each subject what
he thought of the small-step frame-response-mode approach to learning. Twelve per cent of the subjects indicated they thought this was a very good way to learn, 62 per cent indicated they thought this was a good way to learn, 19 per cent indicated that the method didn't make much difference and 7 per cent of the subjects indicated they thought this was a poor or very poor way to learn.

Closely related to Item Number One is Item Number Two on the questionnaire in Appendix B. Item Number Two asked each subject what he thought about the size of the step in going from one frame to the next. Fourteen per cent of the subjects indicated they thought the step size was too large, 18 per cent thought the step size was too small, while 68 per cent thought the step size was about right.

A third item on the questionnaire in Appendix B asked each subject to indicate what per cent of the time his initial responses to the frames in the text were correct. All of the subjects indicated their responses were correct more than 50 per cent of the time. Ninety-six per cent of the subjects indicated their responses were correct more than 75 per cent of the time. Sixty-eight per cent indicated their responses were correct more than 85 per cent of the time and twenty-nine per cent indicated their responses were correct more than 95 per cent of the time.
Checking responses

Item Number Four on the questionnaire asked each subject how often he went back over the materials if his response to a frame did not agree with the answer in the text. Thirty per cent of the subjects checked they always went back over the material in the text to find out why their answer did not agree with the answer given in the text. Fifty-one per cent of the subjects checked they went back over the material most of the time and 19 per cent indicated they went back over the materials half or less than half of the time.

Chapter tests

Item Number Five asked each subject to rate the programmed text in terms of preparing him to take the chapter tests. Thirty-six per cent of the subjects thought the programmed texts were very good in terms of preparing them to take the chapter tests, 38 per cent of the subjects indicated the programmed text had been good for preparing them for the chapter tests, 23 per cent indicated the programmed texts gave them average preparation, and 3 per cent indicated they thought the programmed texts had given them poor preparation for the chapter tests.

Seventy-one per cent of the subjects thought the degree of difficulty of the questions on the chapter tests was about right, 20 per cent of the subjects thought the chapter test
questions were sometimes too difficult, and 8 per cent of the subjects indicated they thought the chapter test questions were too easy.

The instructor in charge of the programmed learning class thought the testing program was a very favorable and essential part of the programmed learning experiment. He believed it was the frequent testing that provided the motivation to keep most of the students committed to studying in their programmed texts.

**Controlled learning**

Item Number Six on the questionnaire explained to each subject that one characteristic of a programmed text is that it relieves the learner of the responsibility to search for new ideas on his own. Item Six went on to ask each subject how he found this characteristic to be. Seven per cent of the subjects indicated they thought the characteristic of being relieved of the responsibility to search for new ideas on their own was very desirable, 59 per cent indicated they thought it was desirable, 27 per cent indicated that it made no difference and only 7 per cent indicated they thought this characteristic was undesirable. The subjects' responses to Item Six reflect an attitude which must have concerned another investigator who wrote, "programed materials inhibit initiative, independence, and responsibility in the learning process, and do not contribute to the achievement of related educational objectives." (May, 1965, p. 8). Perhaps
programers should be more concerned with writing programs
that will help the learner to develop a more searching atti-
tude and a desire to seek out new ideas on his own.

Conventional or programed
instruction

The last item on the questionnaire asked each subject
to suppose he was going to take another mathematics course
and he could choose one course from three different courses
being offered. He was then asked which course he would
choose if the first course employed only programed texts,
the second course employed only conventional instruction and
texts, and the third course combined programed texts with
conventional instruction. Seventy-five per cent of the sub-
jects indicated they would choose the course which combined
programed texts with conventional instruction, 14 per cent
indicated they would choose the class employing conventional
instruction and 11 per cent indicated they would choose the
course which only employed programed texts.
CHAPTER VI
SUMMARY AND CONCLUSIONS

The purpose of the study was to investigate the effectiveness of programed instruction as compared with traditional lecture discussion classes for teaching basic mathematics to college students whose college entrance examination scores indicated they had deficiencies in mathematics. Included in the study was an investigation of the relations of mental ability and study skills to achievement in mathematics when the subjects were taught by conventional procedures and by programed texts. The attitudes of the learner toward programed learning and toward the remedial mathematics course requirement also were investigated.

The subjects for the study were selected on the basis of their grades in high school mathematics and their scores on the mathematics section of the A.C.T. (American College Testing) college entrance examination. Applicants for admission to Utah State University who have a predicted college mathematics grade point of 1.40 or below are required to register for the remedial mathematics course. In the summer of 1965, the Office of Admissions at Utah State University identified over 200 applicants whose predicted grade point average in mathematics was below 1.40. By the beginning of the 1965 fall quarter, 144 of the applicants had registered for the remedial mathematics course. One-hundred thirty-two
of the subjects completed the course and served as samples for the study. Seventy-four subjects enrolled in one section which comprised the experimental group; they used a set of three programed texts for their study of basic mathematics. The other 58 subjects enrolled in a second section which comprised the control group. They studied essentially the same topics in basic mathematics as the experimental group; however, they were instructed by traditional lecture-discussion procedures.

At the beginning of the quarter, the subjects in both groups were given a mental ability test, a study skills inventory, and a standardized general mathematics test. The subjects' scores on these three measures were used as covariates for a covariance analysis of mean scores on a mathematics posttest which was given at the end of the quarter.

The mean score for the entire sample on the mental ability test transformed to the 25th percentile for twelfth grade students. The mean score on the study skills inventory was at the 20th percentile when it was transformed into a percentile score based on normative data for college freshmen. The average grade placement for all the subjects in the experiment, in terms of their scores on the mathematics pretest, was between 8.5 and 9.0. The subjects comprising the sample had evidently not acquired the degree of academic achievement that one would expect if he were to select a random sample of entering college freshmen.
Analysis of variance of the mental ability scores indicated that the mean score for the control group was significantly greater than the mean score for the experimental group. There was no significant difference between the mean scores of the two groups on the study skills inventory. On the mathematics pretest, the difference between the means was not significant for the questions on reasoning (problem solving). However, there was a significant difference between the means in favor of the control group for the questions on fundamentals (computation).

At the end of the quarter, an alternate form of the mathematics test was given to all of the subjects. Analysis of variance of the scores on the mathematics posttest showed there was no significant difference between the means of the experimental group and the control group on the fundamentals questions nor was there a significant difference between the means on the reasoning questions. The experimental group made a greater mean score gain in mathematics fundamentals than the control group did from the mathematics pretest to the mathematics posttest. On the total mathematics test, the experimental group gained 15.19 points and went from a mathematics grade placement of about 8.5 to a mathematics grade placement of about 10.5. The control group gained 11.90 points and went from a mathematics grade placement of about 9.0 to a mathematics grade placement of about 10.5. The analysis of covariance, summarized below, produced significant differences.
There was no significant difference in the variability of the mathematics test scores between the experimental group and the control group. Nor was there a significant change in the variability of the scores from the pretest to the posttest. In other words, the two different teaching methods did not effect different results in the variability of the mathematics test scores.

Correlation coefficients were computed to determine the relation between mental ability scores, study skills scores, and pretest and posttest mathematics scores. Mental ability scores correlated significantly with mathematics test scores, but not with study skills scores. The correlation between study skills scores and mathematics test scores was low, but statistically significant for the experimental group. There was no significant correlation between study skills scores and mathematics test scores for the control group. The correlations between mathematics pretest scores and mathematics posttest scores were high ($r = .79$ to $.81$).

The covariance analysis for the mathematics posttest scores indicated that there were significant mean score differences in favor of the experimental group over the control group on the mathematics fundamentals questions and on the total mathematics test. The difference between the means of the groups for the questions on mathematics reasoning was not significant. The results of the covariance analysis indicated that the subjects who learned from the programmed texts apparently experienced greater achievement in
mathematics fundamentals than did the control subjects who learned from traditional lecture discussion procedures. The programmed learning group also experienced as much achievement in mathematics reasoning as the control subjects did. Furthermore, by taking advantage of individual rates of progress made possible by the programed texts, a considerable number of students in the experimental group were able to cover all the material scheduled for the course before the end of the quarter. However, no delayed retention tests were given to determine how well subjects could recall basic mathematics learned from programed materials as compared to how well subjects could recall basic mathematics learned from conventional procedures. Should this study be repeated, a delayed retention test would certainly be in order. There is also a need for research to determine if programs are available, or if programs can be written, which will be of more assistance to the learner in developing his reasoning or problem solving skills.

It was mentioned previously that mental ability test scores correlated significantly with mathematics test scores for both the experimental group and the control group. These correlations were confirmed when the mathematics posttest mean scores for the high and low mental ability groups were compared within the experimental group and within the control group. The mathematics posttest mean scores for the high mental ability groups were consistently higher than the mathematics posttest mean scores for the low mental ability
groups. The only significant mean score difference, which occurred in the comparison of the experimental mental ability groups mathematics test scores, was a significant mean score difference in favor of the experimental high mental ability group over the control high mental ability group on the mathematics total test.

Not only was there a significant correlation between mental ability and achievement for the subjects who learned from the programs but, except for two, all of the subjects who completed their programs early had mental ability scores above the median for all the subjects in the investigation. Perhaps if time spent learning was not included in the measure of achievement, and if programed materials were used as supplements rather than as entire modes of instruction, the correlation between mental ability and achievement would not be as high as it was in this investigation. The relationship of mental ability to achievement when programed materials are employed as the sole means of instruction as compared with the effect of mental ability on achievement when programed materials are employed as instructional aids has not been determined and warrants investigation.

It was also mentioned previously that the correlation coefficients for study skills scores and mathematics test scores indicated a very small positive correlation for the subjects in the experimental group and no relation between these variables for the subjects in the control group. The
low correlation between study skills scores and mathematics test scores were confirmed when the comparison of the mathematics posttest means for the high and low study skills groups were not significantly different. The results do not corroborate the conjecture that programed materials may be suited best for learners who have weak study skills. In fact, there was an increase in the correlation between study skills scores and mathematics test scores from the mathematics pretest to the mathematics posttest for the subjects who used the programed tests. However, it was noted that the study skills survey was a composite survey of study habits and attitude toward academic achievement. Perhaps the study skills inventory, since it is weighted toward assessing motivation and attitude, does measure something of a student's perseverance to stay with the programed text and thereby learn more from it. Since there was little correlation between the study skills scores and the mathematics test scores for the subjects in the control group, it was not fruitful to compare the relation of study habits to achievement between the experimental and the control groups. This was unfortunate, for there are few reports available on the effects of study habits on learning through programed materials. There is a need to find out if programed materials really do help compensate for poor study habits, but first a more precise measure of study habits than the one used in this investigation must be determined.
At the end of the quarter in which the study was conducted, a questionnaire was given to all the subjects. Three items on the questionnaire pertained to the subjects' interest in mathematics. The null hypothesis of independence was accepted for the comparison of the experimental and control subjects' responses concerning their interest in mathematics before they took the remedial mathematics course and in terms of their increased interest in mathematics as a result of the remedial mathematics course. Seventy-eight per cent of the subjects in the control group and 70 per cent of the subjects in the experimental group indicated that they thought their interest in mathematics had increased as a result of their experience in the remedial mathematics course. The subjects in the control group rated their interest in the conventional remedial mathematics class, compared with their interest in other mathematics classes they had taken, higher than the experimental subjects rated their interest in the programed remedial mathematics class as compared with their interest in other mathematics classes they had taken. A better procedure for determining the effect of a teaching method on changing interest in mathematics than the procedure used in this study would be to obtain a measure of the subjects' interest after the course. Mean scores on these two measures could then be compared within and between the experimental and the control groups.

The experimental subjects' responses to the questions pertaining to their interest in the class nevertheless
generally showed that they thought the class had been interesting. There were some complaints of boredom, but individual pacing, opportunity to take chapter tests twice a week and the understanding by the subjects that they would be excused from the course as soon as they completed their programs and passed the nine chapter tests kept the majority of the students interested and all of the students motivated. The procedure of letting students complete the course before the end of the quarter when programed materials and individual pacing were employed apparently was a successful means of extrinsic motivation. Two students completed the course approximately four weeks before the end of the quarter, six students completed the course two weeks before the end of the quarter and 26 students completed the course approximately one week before the end of the quarter. The mathematical content and topics covered in the programed texts were equivalent to that covered in the control class in which all of the subjects studied the material for the entire quarter. If programed materials of the kind used in this study are used for teaching basic mathematics to remedial students in college, individual pacing and frequent testing with students given the opportunity to be excused from the course whenever they complete the prescribed amount of material, are procedures that appear to motivate the student and contribute to the success of the program.

Other items on the questionnaire pertained to the subjects' attitudes toward their achievement in the course.
One question asked each subject was how much he thought the remedial mathematics course had contributed to his understanding of basic mathematics. A subject's reply to this question is certainly not a valid measure of his achievement in the course, but it is quite likely that his response did indicate something of his attitude toward his achievement in the course. Responses to the different categories for this item were independent of whether the subjects were in the conventionally taught group or the programed learning group. Fifty-seven per cent of all the subjects indicated they thought their knowledge of basic mathematics had increased considerably as a result of their taking the remedial mathematics course.

When the subjects were asked about their attitude toward the university requirement that they take the remedial mathematics course, about 85 per cent of the subjects responded that they were pleased the university gave them the opportunity to take the course and only 15 per cent of the subjects indicated they were sorry the university had required them to take the remedial mathematics course. However, as noted previously, the questionnaire concerning interest and attitude was not given to the subjects until they had completed the course. It is regrettable that no measure of the subjects' attitudes toward the remedial mathematics requirement was obtained before they took the course to compare with the measure of their attitudes after they had taken the course.
Should this study be repeated it would be desirable to obtain pretest and posttest measures of interest and attitude.

The students in the experimental group and the students in the control group were asked to comment on what they thought were the most favorable characteristics of the course. The favorable comment listed most frequently by subjects in the control group was an expression of appreciation that the pace in the course had been slow enough for them to learn subject matter which they had forgotten or they missed in their high school mathematics training. However, it was also the slowness of the group pace that drew the most number of responses pertaining to what the students disliked most about the course. Even though all the subjects in the remedial mathematics courses were selected in terms of their low scores in mathematics, there apparently was still a wide enough range in ability and motivation of the subjects within the control group so that the lack of individualized instruction presented the greatest problem in the class.

The use of programmed materials in the experimental group did eliminate group pacing and it was the individual rate of learning which drew the greatest number of favorable comments from the subjects in the programmed learning group. However, the lack of teacher-group and student-group discussions was the comment listed most frequently by the subjects in the experimental group with regards to what they disliked most about the course. It seems that on the one hand students
want individualized instruction, while on the other hand they want group discussion which in a mathematics class may not be appropriate unless all the students are at the same place in the curricular sequence. Perhaps the best solution to this problem lies in the use of programed materials for individualized instruction with small discussion groups meeting occasionally for students who are studying the same topics. This seems plausible and suggests a need for further research. For instance, research is needed to determine what would be a healthy balance between individualized learning through programed instruction and learning from discussion groups.

The subjects in the experimental group were asked about the small-step frame-response method of learning. Seventy-four per cent of the subjects indicated they thought this was a good way to learn and seven per cent of the subjects indicated they thought this was a poor way to learn. Sixty-eight per cent of the subjects responded favorably to the step size in the programed texts while 18 per cent of the subjects indicated they thought the step size was too small. Ninety-six per cent of the subjects indicated that their responses to the frames in the programed texts were right more than 75 per cent of the time and 81 per cent of the subjects indicated they went back over the programs most of the time to find their errors when their answer did not agree with the one given in the text.
In the review of related studies, one critic of programmed learning (May, 1965) expressed the notion that programmed instruction has too much control over the learner and that programmed materials of the kind presently available tend to reduce the responsibility of the learner to search for new ideas on his own. The subjects' responses to one of the items on the questionnaire used in the present study tended to support the critic's conjecture. When the subjects who had used programmed texts for one quarter were asked what they thought of being relieved of the responsibility to search for new ideas on their own through the use of programmed materials, 59 per cent of the subjects indicated they thought this was desirable and only 7 per cent of the subjects indicated they thought this factor of programmed learning was undesirable. If one of the objectives of mathematics education is to help the learner develop searching attitudes and assume more responsibility in the learning process, then programs of the kind used in this study will evidently contribute little toward this objective. Research is needed to determine if there are programs available or programs can be written which will contribute to the development of searching attitudes.

Finally, this investigation did indicate that programmed texts were as effective as conventional procedures for teaching basic mathematics to remedial college students. In fact, the group which used programmed texts apparently experienced
significantly greater achievement in mathematics funda-
mentals than did the control group which was taught by
conventional procedures. Furthermore, individual rates of
progress, made possible by programed materials, enabled a
considerable number of ambitious students to complete the
equivalent of a quarter's study in basic mathematics in
less than a quarters time.
LITERATURE CITED


Little, J. K. 1934. Results of use of machines for testing and for drill upon learning in educational psychology. Journal of Experimental Education 3:45-49.


The Report of the Committee on Remedial Courses. 1964. Dean of Students, Utah State University. Logan, Utah Mimeo.


APPENDIXES
### Appendix A

### Remedial Mathematics Student Questionnaire

For each of the following, check the response that you feel best answers the question or completes the statement.

<table>
<thead>
<tr>
<th>Number of responses</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
</table>

1. What is the title of the last mathematics course that you took?
   - a. trigonometry 3 1
   - b. second year algebra 5 7
   - c. geometry 7 20
   - d. ninth grade algebra 18 5
   - e. general mathematics in high school 31 20
   - f. ninth grade general mathematics 7 2
   - g. eighth grade arithmetic 2 1
   - **Total**: 73 56

2. How many years ago did you take this course?
   - a. more than ten 1 5
   - b. five or more 11 3
   - c. three or more 21 19
   - d. two 17 12
   - e. one 23 17
   - **Total**: 73 56

3. What grade or mark did you receive in this course?
   - a. A 0 1
   - b. B 8 7
   - c. C 44 37
   - d. D 20 11
   - e. F 1 0
   - **Total**: 73 56

4. The number of students in your high school graduation class was:
   - a. more than 500 23 11
   - b. more than 200 26 31
   - c. more than 100 12 9
   - d. more than 50 6 0
   - e. less than 50 6 5
   - **Total**: 73 56
The following questions refer to Math 0.

5. Before taking this course, my interest in mathematics was
   a. very high 1 1
   b. high 7 4
   c. average 23 22
   d. low 28 21
   e. very low 14 8
   **Total: 73 56**

6. As a result of this course, my interest in mathematics has:
   a. increased considerably 20 17
   b. increased some 31 27
   c. remained about the same 21 11
   d. decreased some 1 1
   e. decreased considerably 0 0
   **Total: 73 56**

7. In terms of interest level, how would you rate this course as compared with other mathematics courses you have taken?
   a. very high 3 8
   b. high 19 22
   c. average 37 19
   d. low 11 6
   e. very low 3 1
   **Total: 73 56**

8. Before taking this course, my knowledge of basic mathematics was:
   a. very good 3 1
   b. good 11 8
   c. average 22 20
   d. poor 29 22
   e. very poor 9 5
   **Total: 73 56**

9. As a result of taking this course, my knowledge of basic mathematics has increased:
   a. very much 19 8
   b. much 21 25
   c. some 30 21
   d. little 1 2
   e. none 2 0
   **Total: 73 56**
10. In terms of the amount you have learned, how would you rate this course with other mathematics courses you have taken?
   a. very high
   b. high
   c. average
   d. low
   e. very low
   
   
11. I found the degree of difficulty of the questions in the text to be:
   a. always about right
   b. nearly always about right
   c. most of the time about right
   d. seldom right
   e. never right

12. I found the content of the course to be:
   a. nearly always too difficult
   b. sometimes too difficult
   c. about right
   d. sometimes too easy
   e. nearly always too easy

13. On the average, for each hour that I spent in this class, I studied outside of class:
   a. more than 3 hours
   b. more than 2 hours
   c. more than 1 hour
   d. some but less than 1 hour
   e. none

Number of responses
Experimental  Control

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>
14. The phrase which best describes your attitude toward the university requiring you to take the remedial course is:
   a. very pleased the University gave me this opportunity
   b. pleased that the University gave me this opportunity
   c. sorry that the University gave me this opportunity
   d. very sorry that the University required me to take it

   Number of responses
   Experimental  Control

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. very pleased</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>b. pleased</td>
<td>42</td>
<td>29</td>
</tr>
<tr>
<td>c. sorry</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>d. very sorry</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

   Total: 73          Total: 56
Appendix B

Questionnaire on Programed Instruction

For each of the following, check the response that you feel best answers the question or completes the statement.

1. I found the practice of breaking an idea up into a list of frames to which I responded was:
   a. a very good way to learn
   b. a good way to learn
   c. didn't make much difference
   d. a poor way to learn
   e. a very poor way to learn

   Frequency: 9, 45, 14, 4, 73

2. I thought the size of the steps in going from one question to the next was:
   a. much too large
   b. too large
   c. about right
   d. too short
   e. much too short

   Frequency: 4, 6, 50, 8, 73

3. In checking my initial responses to the questions in the text, I found them to be right:
   a. more than 95% of the time
   b. more than 85% of the time
   c. more than 75% of the time
   d. about 50% of the time
   e. less than 50% of the time

   Frequency: 21, 29, 20, 3, 73

4. If my answer to a question or problem did not agree with the answer given in the text, I went back over the material or got help to find out why the answers didn't agree.
   a. always
   b. most of the time
   c. about half of the time
   d. seldom
   e. never

   Frequency: 22, 37, 8, 4, 73
5. In terms of preparing me to take the chapter tests, I would rate the programed text as:
   a. very good  
   b. good  
   c. average  
   d. poor  
   e. very poor

6. One characteristic of the programed text is that it relieves the learner of the responsibility to search for new ideas on his own. I found this practice to be:
   a. very desirable  
   b. desirable  
   c. made no difference  
   d. undesirable  
   e. very undesirable

7. If you were going to take another mathematics course and you had a choice between (A) a course employing programed texts only, (B) a course employing regular instruction or (C) a course combining regular instruction with programed texts, which one would you choose:
   a. programed texts only  
   b. conventional instruction and texts only  
   c. combination of programed instruction and regular instruction
VITA

Charles Colven White

Candidate for the Degree of

Doctor of Education

Dissertation: The Use of Programed Texts for Remedial Mathematics Instruction in College

Major Field: Secondary Education

Biographical Information:

Personal Data: Born at Salt Lake City, Utah, September 29, 1932, son of Charles T. and Olive M. White; married Colleen Patricia Burleigh February 9, 1952; four children—Kathleen, Guy, Kevin and Maria.

Education: Graduated from West High School in Salt Lake City, Utah, in 1950; received the Bachelor of Science degree in 1958, the Master of Education degree in 1964 and the Doctor of Education degree in 1969 from Utah State University; specialized in mathematics education and curriculum development; did some graduate study at the University of Illinois in 1962, and San Jose State College in 1962-63.

Professional Experience: 1964 to present, instructor, Department of Mathematics, Utah State University; secondary school mathematics instructor in Logan City Schools, Logan, Utah, from 1958 to 1962.