A STUDY OF PROGRAM SEQUENCING IN COMPUTER-ASSISTED INSTRUCTION

by

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ABSTRACT

This study was undertaken to investigate how program sequencing would effect a sixth-grade group of Ss. A linear program of 111 frames that taught base five arithmetic was chosen for the study. The program presented in its original order was called the logically sequenced program. The program whose frame sequence was determined by a table of random numbers was called the scrambled sequenced program.

On the basis of IQ scores, two groups of students were formed. Equal numbers from each of these two groups were then assigned at random to one of the two programs of instruction. The two programs of instruction were presented to the Ss by means of computer terminals. A posttest was then administered to test the effect of program sequencing on learning facts and skills that were taken directly from the program. Also tested was the effect of program sequencing on the student's ability to use the principles developed in the program to solve problems that are an extension of these principles.

There was found to be a significant increase in the program error rate and program completion time for the scrambled sequenced program when compared to the logically sequenced program, implying that the program chosen for the study contained dependency among the frames. The results of the

posttest indicated that there was no significant difference between the mean scores of the two groups although in each case the logically sequenced group did achieve a higher mean score. It was also found that there was no significant interaction between sequence of instruction and ability level.

Many previous studies in program sequencing have dealt with an older population in comparison to the population chosen for this study. The conclusions from these studies have generally been that sequence of instruction has been overemphasized as a variable for consideration in program construction. While the results of this study indicate that sequence of instruction may be more important for a younger population, some doubt is raised as to the importance of attempting to obtain a carefully sequenced, small error rate program.

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CHAPTER I

THE PROBLEM

BACKGROUND

The careful sequencing of instructional stimuli has generally been considered of prime importance in the planning of programed instruction. Skinner's (22:169) definition of programing as the "construction of carefully arranged sequences of contingencies leading to the terminal performances which are the object of education" has had a tremendous effect on sequencing of programed instruction. Skinner suggests that individual programing makes it possible to present small step, carefully sequenced items where a solution to each problem depends upon a correct response to the preceding one and through this process, an eventual complex repertoire is made.

Following an experiment dealing with a carefully ordered sequence of learning items, Roe, Case, and Roe (21:101) concluded:

> ...the importance of the careful ordering of items became suspect when it was discovered that a student, who failed to read the introductory instructions of the programed testbook, read down the page instead of from page to page so that the sequence of items was numbered 1, 40, 79, 118, 157, 2, 41, 80, 119, 158, 3, 42,and so on. This student still managed to get a high score on the criterion test.

Several studies have since been conducted to test the importance of a logically sequenced instructional unit as opposed to a scrambled sequence of the same material content. In almost every instance, the results of the study have indicated that there is no significant difference between the two types of presentation.

Levin and Baker (13), when discussing the effects of item scrambling, concluded that program content was probably an important factor to consider when studying the effects of program sequence on learning. Since Levin and Baker's study, the studies that have been done concerning sequencing of instruction have generally attempted to use a program in which the mastery of some concepts were a prerequisite to the mastery of other concepts and principles in the program.

The model usually followed to describe such hierarchial learning is Gagné's hierarchy of learning model (Niedermeyer, 17:302-303). When the first principle to be learned is considered, it can be analyzed into a number of subordinate concepts which must be mastered if the final task if to be attained. These concepts in turn depend upon other subordinate concepts which are eventually reduced to stimulus-response type learning. What is being developed is a hierarchy of sub-knowledge that grows increasingly simple. Once the heirarchy is determined, it is possible to organize a sequence of instruction for the final performance to be attainable.

The method or analysis of the task is begun, as Gagné (9:4) suggests, by asking the question "...what would an individual have to know how to do in order to achieve successful performance of this class of task, assuming he were given only instructions?" This analysis is then repeated on each learning task until the entire hierarchy is defined. Gagné believes that if the hierarchy of learning model is followed, the learning of a high order principle can be made meaningful.

The problem has been that Gagné's hierarchy is a learning theory and Gagné says that some things must be learned before others (Niedermeyer, 17:314). Gagné's (7:624) studies have in fact shown that some of the concepts underlying a principle must be known before the principle is understood. As Niedermeyer (17:314) has concluded from his studies in program sequencing, the sequence of learning is different from the sequence of instructional frames or stimuli. When students miss frames that are necessary for the understanding of a concept, they are unable to answer the question on the concept correctly and this causes the program error rate to increase. It is quite possible that the concept will be learned either through the correct answer being supplied in the program or through reorganization by the student, when he eventually comes to the prequisite skills.

If the objective of a program of instruction is simply to have students learn program content, then this outcome may not be affected by the method of sequencing. On the other hand, if it is desired that there be an understanding of the principles taught in the program for extension to new, though related problems, it seems questionable that a program presented in a scrambled version could be capable of providing the student with the necessary understanding of the principle.

Another dimension of consideration in the area of program sequencing is intelligence. Students of low intelligence may not be as capable of organizing a scrambled program of instruction as students of high ability. While some previous studies have considered ability as a variable interacting with sequencing, there appear to be no clear results from these studies.

The problem of careful sequencing of program material is fundamental for Computer Assisted Instruction (CAI) where there exists many possibilities for the organization and sequencing of course materials. While there are obvious differences in the many different systems for CAI, most systems have the flexibility of course organization and sequencing and the adaptability of sequencing for the individual. Despite the efforts to make the sequencing of instruction flexible, studies by Niedermeyer (17), Wodtke (26), and Payne (19) suggest that a carefully organized sequence of instruction provides for no more significant learning than a completely randomized sequence.

Statement of the problem

The following questions will be considered:

1. Does program sequencing have an effect on learning program facts and skills?
2. Does program sequencing have an effect on learning principles applicable to problems not included in the program?

3(a). Is there an interaction between sequence of instruction and ability level on learning program principles applicable to problems not included in the program?

3(b). Is there an interaction between sequence of instruction and ability level of learning program facts and skills?

CHAPTER II

REVIEW OF THE LITERATURE

The problem of deciding when a program is logically sequenced and contains frame dependency has been tested using the criterion that the presentation of a logical sequence in a scrambled order should cause the Ss to make significantly more within program errors as they continue through the program when compared to the program in its original order (Niedermeyer, 17:302). The rationale underlying this reasoning is that if a program contains no frame dependency, then there should be no significant difference in the error rate however the program is sequenced.

Using program error rate as a criterion measure, Holland (11:69) pointed out that the two program error rates in the study by Roe, Case, and Roe did not differ significantly, suggesting that the items in the program were not highly interdependent. After the investigation by Holland, Roe revised the earlier program and this time the logical version did produce significantly better results, apparently satisfying both Holland and Roe that careful sequencing of instructional material is an important criterion for program construction. However, several studies of the problem conducted since the one by Holland, and using the criterion of program error rate to determine a logically sequenced program of instruction, have reported "no significant difference" between the means on posttest scores between the logical and scrambled program groups.

A study by Payne, Krathwohl, and Gordon (19) was conducted to examine the effects of sequencing on the learning of three college statistics programs. While scrambling of items was done by a table of random numbers, it was found that there were no treatment effects and also no interaction between ability and sequencing. The fact that the error rate for the scrambled versions of the program were low, between four and six percent and not significantly different from the logical version, indicates that either the Ss had some prior knowledge of the material or that the program chosen for the study did not have frame dependency. A second limitation of the study was that the programs were presented in booklet form and the students were allowed to complete the program at their own leisure in an uncontrolled situation.

In a study conducted by Wodtke, Brown, Sands, and Fredericks (26), a program on number bases was presented to 80 education majors at Pennsylvanis State University by means of computer terminals. The program would appear to contain items that were interdependent since there was a significant increase in the "within program error rates" when the scrambled version of the program was compared to the logical version.

Another criterion measure which was used to lend support to the argument that the logical version contained frame dependency was that the instructional time increased by a significant amount when the program was presented in a scrambled order. The reasoning underlying this argument was that instructional time should increase if Ss have to puzzle over frames in a scrambled sequence in comparison to a logical sequence.

The skills measured in the program were conversion of a number in any base, not equal to ten, to its base ten equivalent and conversion of a number from base ten to any other base. The study seemed to be well controlled and a pretest of the Ss indicated that they had little prior knowledge in the area of instruction. The findings of the study were no significant difference between the two sequences of instruction with regard to either posttest scores on factual material presented in the program or transfer tasks (Wodtke et al., 26:62). The investigators themselves expressed surprise as to the results of the experiment since they felt the study had many controls that earlier studies had lacked. They (Wodtke et al., 26:67) concluded:

> The ability to reorganize scrambled material is undoubtedly a function of the cognitive development of the learner. Although it appears likely that college students are able to accomplish such reorganization, the writers would be extremely reluctant to generalize such a conclusion to the problem of sequencing learning

> materials for young children. It may be that sequencing is much more crucial in the education of young children who have not yet developed their own learning strategies.

Another interesting aspect of Wodtke's study is that the examination of the aptitude by sequence interactions provided support for the argument that a logically sequenced program of instruction is more important for students of low ability. While the results were not significant ($P = .114$), the obtained α tends to support the argument.

In a study conducted by Stolurow (23) using a "mixed" sequence and a "consecutive" sequence to teach fractions to educationally handicapped high school students (mean mental age of 12.25 years) the question of interaction between sequencing and I.Q. scores was investigated. It was found that I.Q. correlated .61 with posttest scores for students given the mixed program but did not correlate significantly with performance on the consecutively sequenced program. Stolurow (23:351) interprets these results as suggesting "the best sequence did for the poorest ability group what the highest ability groups could do for themselves regardless of sequence." When considering these results with other studies dealing with university students of higher intelligence, this study also suggests that sequencing may be more important for younger children or _S_s with low I.Q.

A study dealing with a younger population was conducted by Niedermeyer (17) when a group of grade nine students was presented with a program on number series in a logical, scrambled and reverse order. The program consisted of an introduction to a number series and eventually introduced the problem solving skill of finding a formula for the sum of n terms of a series. While program error rates did differ significantly ($p < .05$) in favour of the logical sequence, none of the sequenced groups differed significantly from each other on either a test of factual material or transfer of problem solving skills. There was also no evidence of sequence by I.Q. interaction.

There appear to be two possible explanations for the failure of Niedermeyer's study to provide evidence of any significant difference between the three programs of instruction. While the error rates of the scrambled and reversed sequenced groups differed significantly from the logical sequence, the error rate for the logically sequenced program was 35 percent. The program used for the study was obtained from Gagné and Brown's (8) study dealing with discovery learning and the program error rate in their experiment was much lower, indicating that perhaps the program was too difficult for the students used in the study by Niedermeyer. Another factor that could have led to the large error rate was the fact that the original program consisted of 129 frames and Niedermeyer used a revised form of the program consisting of 110 frames. Perhaps some of the frames that were removed were more essential to the understanding of the other frames in the program than appeared to be the case when they were removed.

Brown (2), who was doing experimental work with Niedermeyer, also examined the effects of sequencing on the learning of the number series program that Niedermeyer had used but chose as the Ss, students from the eleventh-grade. The original program that had been written by Gagné and Brown, was used for this study rather than the shortened version that Niedermeyer had used.

The completion time and the program error rate for the scrambled version increased significantly when compared to the logical sequence again suggesting that the program contained frame dependency.

There was no significant treatment effect found on the posttest results of on-route tasks when the logical and scrambled groups were compared. Nor was there any significant IQ by sequence interaction. However, on the posttest scores of problem-solving tasks, the group receiving the logical sequence performed significantly better than the scrambled ordered group. The IQ by sequence interaction was not statistically significant.

While the results of the study are in contrast to the study by Niedermeyer, it does indicate that scrambling the order of items may make little difference if the tasks being taught can be classified as learning facts and skills, but if the tasks are complex problem-solving behaviors, then perhaps sequence may have an important effect upon learning.

CHAPTER III

DESIGN OF THE STUDY

INTRODUCTION

From the previous discussion on program sequencing, it becomes apparent that some students have the ability to reorganize a poorly sequenced program of instruction. Studies to date imply that at least for students at a university level, careful sequencing of instruction may not be as important a criterion for program construction as was once so commonly thought to be the case. Before these results can be generalized, the importance of sequencing needs to be studied more carefully with a pre-university group.

The program chosen for this study was a linear program to teach base five arithmetic. The original version of the program was used by Floyd (5) in a study comparing the effectiveness of a branching program with the effectiveness of a linear program. The linear program was found to be successful in teaching base five arithmetic to sixth-grade students, for whom the program was written. A pilot study, conducted by the examiner, indicated that the program contained frame dependency since there was a significant increase in error rate when a scrambled version of the program was compared to the original version.

DEFINITION OF TERMS

(a) scrambled sequence of instruction: a program of instruction that has had its frame sequence of presentation determined by a table of random numbers.

(b) logical sequence of instruction: a small-step program of instruction that has been found to have a significantly lower program error rate when compared to a scrambled version of the same frames.

(c) extension questions: questions that are different from what was taught in the program but which require the concepts and principles developed in the program for their solution.

FORMATION OF THE GROUPS

The population

The population consisted of sixth-grade students from elementary schools in Vancouver. The students were on the regular British Columbia program and it was found in this study and in the study by Floyd (5:14) that grade six students had sufficient background for elementary base five arithmetic, but had little opportunity for exposure to the topic since its introduction is usually encountered in seventh-grade.

The sample

The sample was chosen from grade six students in a single school due to transportation and administrative difficulties. Thirty-six students were selected at random, using a table of random numbers, from the two classrooms of students in the school. An IQ score for each of the Ss was made available to the investigator by the school and the IQ test administered was the Otis-Alpha Quick-Scoring Mental Ability Test. The median IQ for the sample was 116 and ranged from 87 to 150. The students were then grouped into high and low IQ groups, each having eighteen members. The students from the two groups were then assigned, using a table of random numbers, to one of the two programs of instruction.

DEVELOPMENT OF MATERIALS

Program content

The logical sequence of instruction consisted of 111 frames and presented subsets of items in the following order:

1. Review of the base ten number system and the concept of place value.
2. Instruction in how to write a numeral to represent a number in bases less than ten.
3. A discussion of the numerals required in base five arithmetic and base five counting.
4. A development of base five addition facts, up to adding two two-digit base five numerals.
5. The use of a base five addition table.
6. Multiplication of base five numerals by the numeral two.

The program was written in such a way that the student was required to respond to a question presented in each frame. The response was then evaluated and if the answer was correct, the student was so informed and then the next frame was presented. If the answer was incorrect, the correct answer would be given and the next frame presented. The complete trace of the text material and student response for student number one in the logically sequenced group, high IQ, may be found in Appendix I.

The scrambled version

Using a table of random numbers, four scrambled sequences were generated from the frames of the logical version. The Ss in the scrambled sequence group were then assigned to one of these four scrambled sequences at random. Appendix II lists the order of frame presentation for each of the four scrambled sequences.

Posttest measures

The independent variables were the two sequence conditions and IQ. The dependent variables were time to complete the program, errors made on the program during instruction, and scores on the posttest.

The test instrument was the one developed by Floyd and was found by her (5:20) to have a reliability coefficient

(Kuder-Richardson Formula 20) of 0.92. The test of criterion skills consisted of 12 questions dealing with tasks taken directly from the program and 30 extension questions.

The extension questions were chosen from the following areas:

1. Addition in base five of
   (a) three two-digit numerals
   (b) two three-digit numerals.
2. Multiplication in base five of
   (a) three-digit numerals by two
   (b) two-digit numerals by numbers greater than two.
3. Counting
   (a) in base five beyond 30
   (b) in base four.
4. Using a base eight addition table to
   (a) add two two-digit numerals.
   (b) multiply two-digit numerals by two.
5. The numerals that are used in base six.
6. Deduction of the base being used.
7. Conversion from one base to another.
8. Development of a base four addition table.
9. Subtraction in base five.
10. Development of a base five multiplication table.

The posttest is found in Appendix III.

PROCEDURE

The 36 grade six students in the experiment were brought to the University of British Columbia to work on the programs of instruction. The course was programed for presentation to the Ss via three teletypewriter terminals using the Coursewriter III language. The terminals were connected to the University of British Columbia IBM 360/67 computer. Depending on whether the student was in the logically sequenced group or the scrambled sequenced group, the program that was presented was either the logical version or one of the four scrambled versions. Each student was given an introduction to the use of the terminal before the program of instruction began.

Immediately after completing his program, each student wrote the posttest. The time for the students to complete the program and write the test was approximately two hours.

STATISTICAL ANALYSIS

Statement of hypotheses

In order that the program of instruction may be considered to have frame dependency and be logically sequenced, it is necessary that there be a significant increase in the program error rate and the program completion time when the logical program is compared to the scrambled program. Following are the hypotheses tested:

H1. There is no significant difference in the program error rates between the logically sequenced group and the scrambled sequenced group.

H2. There is no significant difference in the program completion time between the logically sequenced group and the scrambled sequenced group.

The questions presented on page 5, in Chapter I, are stated below as null hypotheses:

H3. There is no significant difference between the means of the posttest scores of program facts and skills for the two groups dependent on a logical or scrambled sequence of instruction.

H4. There is no significant interaction between sequence of instruction and ability level on learning program facts and skills.

H5. There is no significant difference between the means of the posttest scores of extension questions for the two groups dependent on a logical or scrambled sequence of instruction.

H6. There is no significant interaction between sequence of instruction and ability level on solving extension problems.

<u>Data</u>

For each student, two posttest scores were obtained. One score (out of 12) corresponded to the number of correct responses to the test on criterion skills and the second score (out of 30) corresponded to the number of correct responses to the extension questions.

Statistical treatment of data

The number of program errors, the program completion time and the two posttest scores were analyzed by means of a two factor design analysis of variance with an α level of .05. The following mean scores tabulated made for the four dependent variables:

TABLE I

THE TWO FACTOR DESIGN

	High IQ	Low IQ	
Logical Sequence	$\bar{X}_{11}$	$\bar{X}_{12}$	$\bar{X}_{1.}$
Scrambled Sequence	$\bar{X}_{21}$	$\bar{X}_{22}$	$\bar{X}_{2.}$
	$\bar{X}_{.1}$	$\bar{X}_{.2}$	

CHAPTER IV

ANALYSIS OF THE DATA

RESULTS OF THE STUDY

Means of the groups

The complete tabulation of the program errors, the program cpmpletion time and the posttest scores for each of the Ss may be found in Appendix IV. As outlined in Table I, the means of each group for program errors, the program completion time and the two posttest scores are presented in Tables II, IV, VI, and VIII respectively.

ANALYSIS OF THE HYPOTHESES

Hypothesis I

Hypothesis I stated that there would be no significant difference in the program error rates between the logically sequenced group and the scrambled sequenced group. The analysis of variance with program errors as the dependent variable is summarized in Table III. Since the desired α of .05 was attained, the null hypothesis was rejected and it was concluded that the scrambled sequenced group produced significantly more program errors than the logically sequenced group.

It should be noted that the asterisks used in all the analysis of variance tables indicates that the F-ratio was significant. It will also be noted that there was a significant difference between the mean scores of the high IQ group and the low IQ group in program errors, program completion time, and the posttest scores of program facts and skills. This was expected when the variable IQ was dichotomized and was not considered as part of the hypotheses.

TABLE II

MEANS OF PROGRAM ERRORS

	High IQ	Low IQ	
Logical Sequence	13.67	23.22	18.44*
Scrambled Sequence	28.89	37.22	33.06*
	21.28*	30.22*	25.75**

*Group means
**Grand mean

TABLE III

ANALYSIS OF VARIANCE FOR HYPOTHESIS I

Source of Variance	df	ss	MS	F
Sequence	1	1921.36	1921.36	16.03*
IQ	1	720.03	720.03	6.01*
Sequence X IQ	1	3.36	3.36	0.03
Error	32	3835.97	119.87	

Hypothesis II

Hypothesis II stated that there would be no significant difference in the program completion time between the logically sequenced group and the scrambled sequenced group. The analysis of variance with completion time as the dependent variable is summarized in Table V. From these results, the null hypothesis was rejected and it was concluded that the scrambled sequenced group took significantly more time to complete the program than the logically sequenced group. Thus the rejection of hypotheses I and II indicated that the program of instruction used in the study satisfied the definition of a logically sequenced program of instruction.

TABLE IV

MEANS OF COMPLETION TIME
(IN MINUTES)

	High IQ	Low IQ	
Logical Sequence	63.33	73.67	68.50*
Scrambled Sequence	68.56	78.78	73.67*
	65.94*	76.22*	71.08**

*Group means
**Grand mean

TABLE V

ANALYSIS OF VARIANCE FOR HYPOTHESIS II

Source of Variance	df	ss	MS	F
Sequence	1	240.25	240.25	4.32*
IQ	1	950.69	950.69	17.09*
Sequence X IQ	1	0.03	0.03	0.00
Error	32	1779.78	55.62	

Hypothesis III

Hypothesis III stated that there would be no significant difference between the means on the posttest of program facts and skills for the logically sequenced group and the scrambled sequenced group. The analysis of variance for this posttest measure is in Table VII. On the basis of these results, the null hypothesis was not rejected and it was concluded that there was no significant difference between the means on posttest scores of program facts and skills.

Hypothesis IV

Hypothesis IV stated that there would be no significant interaction between sequence of instruction and ability level on a test of program facts and skills. The analysis of variance for this posttest measure is in Table VII. On the basis of these results, the null hypothesis was not rejected and it was concluded that there was no significant interaction between sequence of instruction and ability level for this posttest measure.

TABLE VI

MEANS OF THE TEST OF PROGRAM FACTS AND SKILLS

	High IQ	Low IQ	
Logical Sequence	10.11	7.22	8.67*
Scrambled Sequence	7.33	6.00	6.67*
	8.72*	6.61*	7.67**

*Group means
**Grand mean

TABLE VII

ANALYSIS OF VARIANCE FOR HYPOTHESES

III AND IV

Source of Variance	df	ss	MS	F
Sequence	1	36.00	36.00	3.89
IQ	1	40.11	40.11	4.33*
Sequence X IQ	1	5.44	5.44	0.58
Error	32	296.44	9.26	

Hypothesis V

Hypothesis V stated that there would be no significan difference between the mean scores for the two groups on a test of extension problems. The analysis of variance for this posttest measure is in Table IX. On the basis of these results, the null hypothesis was not rejected and it was concluded that there was no significant difference between the means of the two groups for this posttest.

Hypothesis VI

Hypothesis VI stated that there would be no significant interaction between sequence of instruction and ability level on a test of extension problems. The analysis of variance for this posttest measure is in Table IX. On the basis of these results, the null hypothesis was not rejected and it was concluded that there was no significant interaction between sequence of instruction and ability level for this posttest measure.

TABLE VIII

MEANS OF THE TEST OF EXTENSION PROBLEMS

	High IQ	Low IQ	
Logical Sequence	17.89	12.44	15.17*
Scrambled Sequence	13.56	10.78	12.17*
	15.72*	11.61*	13.67**

*Group means
**Grand mean

TABLE IX

ANALYSIS OF VARIANCE FOR HYPOTHESES

V AND VI

Source of Variance	df	ss	MS	F
Sequence	1	81.00	81.00	2.18
IQ	1	152.11	152.11	4.09
Sequence X IQ	1	16.00	16.00	0.43
Error	32	1190.88	37.22	

EXPLICATION OF THE RESULTS

The program of instruction

The null Hypotheses I and II were rejected, thus implying that the program used in the study contained frame dependency and satisfied the definition of a logical sequence of instruction. It was generally observed that the error rate started high for each of the *Ss* in the scrambled sequenced group as the student encountered problems for which he still did not have the prerequisite knowledge. It seemed that as more of the prerequisite knowledge was gathered together by the student, the error rate gradually decreased to the same rate as the logically sequenced group. While scrambling a program of instruction which has dependency among the frames does increase the number of errors at the beginning of the program, the Ss apparently are able to organize the necessary prerequisite skills so that by the end of the program, they are performing at the same level as students in the logical program.

The same observation could be made for program completion time. At the start of the program, the Ss in the scrambled group were puzzled by a question for which they did not have the necessary prerequisite skills to answer, and they simply had to guess at the correct answer. As the necessary prerequisite skills were eventually assimilated, the amount of response time to the question presented became approximately the same as the logically sequenced group.

The posttest scores

While the logically sequenced group did not perform significantly better than the scrambled sequenced group on either the test of program facts and skills or the extension problems, it was observed that in each case, the mean score for the logically sequenced group was greater than for the scrambled sequenced group. Although the obtained F value, 3.89 was not significant, the difference between the scores of the two groups on program facts and skills tended toward significance ($.05 < p < .10$). From the previous studies done in program sequencing, it was expected that there would be very little difference between the two groups on this posttest measure. It seemed possible that these facts and skills could be learned from a scrambled program, either through the correct answer being supplied in the program, or through the reorganization by the student when the prerequisite skills are eventually met. When questions concerning these facts appeared in the posttest, he would be able to answer the questions correctly.

The difference between the scores of the two groups in the test of extension problems did not even meet the ten percent level of significance and it was the experimenter's belief that the difference between the two groups would be greater in the posttest of extension problems than in the posttest of program facts and skills. That the students in the scrambled sequence learned these facts and skills through their eventual appearance in the program was not surprising, but it seemed doubtful that they would be able to assimilate the program material to solve the extension problems. Perhaps the concepts and principles that were developed in the program were what Brown (2:44) calls "low order principles." Even though the program was presented in a scrambled order, the Ss were still able to understand these principles and apply them to solve the extension problems.

The IQ by sequence interaction for each of the two posttest measures has been plotted in Figures 1 and 2. In each case, there is no indication that the scrambled sequence

FIGURE 1

MEAN POSTTEST PERFORMANCE ON PROGRAM FACTS AND SKILLS

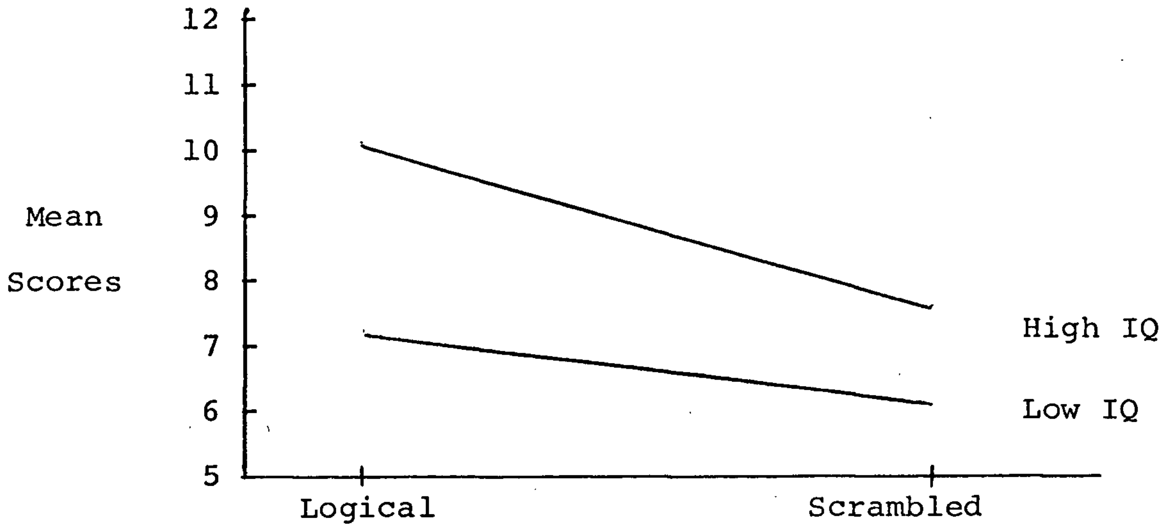
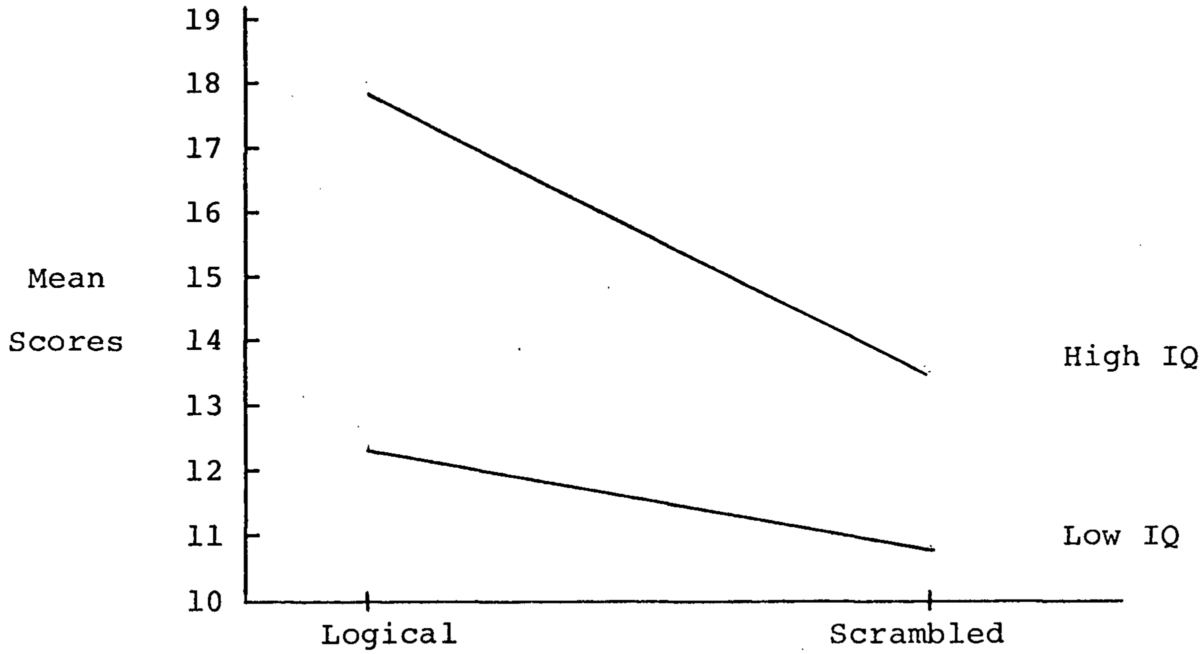


FIGURE 2

MEAN POSTTEST PERFORMANCE ON EXTENSION PROBLEMS



of instruction had a more detrimental effect on the performance of the low IQ group than the high IQ group. The *S*s in the study were above average in ability and perhaps, as Stolurow (23) found, ability by sequence interaction is significant only at very low ability levels.

CHAPTER V

CONCLUSION AND SUMMARY

THE EFFECTS OF COURSE SEQUENCE

While the present study dealt with a population that was younger than the population in most of the previous studies, the results of the investigation are in close agreement with many of the earlier findings, which indicate that the effects of a scrambled sequence of instruction may not be as detrimental to the learning of programed material as was originally considered to be the case.

The results did show that scrambling a logically sequenced program of instruction decreased the efficiency of the program as measured by the significant increase in error rate and completion time. Scrambling did not significantly effect student performance on learning program facts and skills or solving extension problems.

The study attempted to control many of the limitations of previous studies. Neither the study by Krathwohl, Payne, and Gordon nor Roe, Case, and Roe discussed in Chapter I found significant difference in the number of errors committed during instruction between the logical and scrambled sequenced groups. As a conclusion to their studies, the impression was given that a program of instruction that failed to produce any significant difference in error rate when scrambled, could not be considered to have frame dependency, and could hardly be expected to have any effect on the amount learned from the scrambled program in comparison to the original version.

Another criticism that has been offered in the studies of program sequencing is that scrambling the order of short programs of instruction may make little difference to the desired outcomes. Evans (4:386) has stated that "...it seems highly unlikely that any successful, well revised program of more than 100 frames in length, in highly structured topics such as mathematics or logic, could be successfully scrambled in its entirety and still do the job it was designed to do." The program chosen for this study satisfied Evans' criteria and it was still found that scrambling of frames had no significant effect on posttest scores.

There was no indication of interaction between IQ and sequence of instruction and this result is in agreement with many of the previous studies. It was observed that for both posttest scores, the mean scores for the high IQ groups differed by a greater amount than the mean scores for the low IQ groups. Stolurow (23) found that program scrambling had a more detrimental effect on the learning of the low IQ group than the high IQ group, but the students in his study were educationally handicapped. The Ss in this study were above average in ability (median IQ 116) and perhaps the low IQ group was much more able to reorganize the scrambled sequence by themselves than was the case in the study by Stolurow.

LIMITATIONS OF THE STUDY

The program of instruction

The performance level reached by the logically sequenced group on the posttest scores of program facts and skills was an average score of 72 percent. It could be argued that the program was only partially successful in the instruction of the program material and thus it is unreasonable to expect a large difference between the program and a scrambled version of the program.

The sample

As was discussed in Chapter III, the students in the study attended one school so that they probably were not a representative sample of the sixth-grade population. The students attending the school generally have above average ability and this might tend to lessen the interaction between ability and sequencing.

The Hawthorne effects

Since the treatment method necessitated a change from the students daily routine, undoubtedly the change influenced the results of the study. It was assumed that since both groups were subject to the same conditions, this effect was equal for both groups.

It was not possible to assign all students to the teletypewriter terminals at the same time, and it is probable that some of the students who were later in their assignment to the terminal could have gotten information about the study from their predecessors.

It was also necessary to tell several students in the scrambled sequenced group that they should continue with their program of instruction, even though they were unable to answer some of the questions correctly. Some students, near the beginning of the program, were concerned about making errors and would ask for assistance from the examiner. This interaction did not exist with the logically sequenced group.

IMPLICATIONS FOR FURTHER RESEARCH

The experimenter suggests further research in the area presented in this thesis where a more representative sample of the sixth-grade population than the sample chosen in this study would be used. If possible, in further studies, the Ss should be assigned simultaneously to the teletypewriter terminals. Even though there was a lack of significant difference between the means on the posttest scores for the two groups, it is important to note that in the study by Wodtke (26), the mean scores on the posttest were greater for the scrambled sequenced group than the logically sequenced group. This may indicate that perhaps sequencing of instruction should be considered more carefully with a younger group of Ss as was originally suggested. However, the writer would agree with the observations drawn from previous studies by Wodtke (26) and Niedermeyer (17) that there may be more important factors contributing to the variance in students learning compared to the manipulation of the sequence of instruction.

It is apparent from the observation of posttest scores for students in the scrambled sequenced group (see Appendix IV) that some students have excellent organizational skills. Studies dealing with organizational patterns employed by students might provide more information for the optimization of programed instruction than the manipulation of a sequence of instruction.

SUMMARY

This study was undertaken to investigate the effects of scrambling a logical sequence of instruction when dealing with a sixth-grade sample. While it was expected that the scrambled sequence of instruction would not effect the learning of facts and skills developed in the program, it was felt that the scrambled sequence would be detrimental to the learning of principles developed in the program which were needed to solve the extension problems. In each case, there was found

to be no significant difference between the logically sequenced group and the scrambled sequenced group. However, there was a tendency toward significance ($.05 < p < .10$) between the mean scores on the test of the program facts and skills.

The results of this study do not mean that course sequencing in the writing of a program of instruction is not important, but perhaps these results, together with many previous studies, raise some questions on the importance of finding the ultimate sequence containing small steps and minimal error rate. It may be that students are better able to cope with a scrambled sequence on instruction than had been considered possible, and instructional sequencing may be a somewhat overrated variable in program construction.

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A P P E N D I C E S

APPENDIX I

THE COMPUTER PRINT OUT OF THE TEXT MATERIAL AND A STUDENT'S RESPONSE

```
Frame #    Actual Text

1
     IN THE NUMERAL 26, WHICH OF THE FOLLOWING
     DOES THE 2 REPRESENT?
        2    20    200    2000
     20
     CORRECT
2
     IF THE 2 IN 26 REPRESENTS 20, WHAT DOES THE 6 REPRESENT?
     6
     GOOD
3
     26 = 20 + 6
     WHICH WE CAN WRITE AS
     26 = 2 X 10 + 6
     SO THE 2 IN 26 TELLS YOU THERE ARE 2 ...'S
     10
     CORRECT
4
     LOOK AT THE NUMERAL 84.
     84 = 8 X ... + 4
     10
     CORRECT
5
     84 = 8 X 10 + 4
     YOU CAN SEE HOW IMPORTANT 10 IS IN OUR COUNTING SYSTEM.
     OUR COUNTING SYSTEM IS BASED ON 10, AND WE SAY THAT WE
     COUNT IN BASE 10.  HOW MANY FINGERS DO YOU HAVE (INCLUDING
     THUMBS ) ?
     10
     CORRECT
6
     A LOT OF PEOPLE COUNT ON THEIR FINGERS.  THAT PROBABLY
     EXPLAINS WHY WE COUNT IN BASE ....
     10
     CORRECT
7
     BEFORE SOMEONE THOUGHT OF NUMBER BASES THEY HAD TO WRITE
     NUMERALS BY MAKING A TALLY LIKE THIS
     / / / / / / / / / / / / / / / / / / / / / / / / / /
     WOULD THIS TAKE LONGER THAN OUR USUAL WAY OF WRITING
     NUMERALS?  ANSWER YES OR NO.
     YES
     THAT IS CORRECT
8
     A CLEVER PERSON INVENTED A SHORT CODE TO SAVE A LOT
     OF TIME.  HE DECIDED TO COUNT IN TENS AND SEE HOW MANY
     GROUPS OF TEN HE COULD MAKE.
     / / / / / / / / / / / / / / / / / / / / / / / / / /
     HOW MANY GROUPS OF TEN COULD HE MAKE FROM THIS TALLY?
     2
     CORRECT
```

Frame # Actual Text

9

WHEN GROUPS OF TEN ARE MADE FROM THE FOLLOWING TALLY,
/ /
HOW MANY ARE LEFT OVER?
6
GREAT

10

THE CODE FOR
/ /
WAS 26, SINCE THERE WERE 2 GROUPS OF 10 AND 6 WERE LEFT
OVER IN THE CODE,THE 2 IN 26 REPRESENTS 2 X ...
100
NO, THE 2 REPRESENTS 2 X 10 X

11

EVERYBODY WHO KNEW THE BASE 10 CODE, KNEW THAT WHEN HE
WROTE 57 THE 5 REPRESENTED 5 X ...
10
THAT IS CORRECT

12

IF YOU DID NOT WANT TO COUNT BY TENS AND DECIDED TO USE
A BASE EIGHT CODE, YOU WOULD THEN MAKE AS MANY GROUPS
OF .... AS YOU COULD.
8
CORRECT

13

FROM THE FOLLOWING TALLY,
/ /
HOW MANY COMPLETE GROUPS OF EIGHT CAN YOU MAKE?
3
THAT IS CORRECT

14

WHEN GROUPS OF EIGHT ARE MADE FROM THE FOLLOWING TALLY
/ /
HOW MANY ARE LEFT OVER?
2
YES, THE ANSWER IS 2

15

SINCE YOU COULD MAKE 3 GROUPS OF 8 AND HAVE 2 LEFT OVER
FROM THE TALLY //////////////////////////, YOU
WOULD WRITE 32 IN THIS CODE. SAY THIS TO YOURSELF AS
THREE-TWO . DON'T SAY THIRTY-TWO BECAUSE IT DOES NOT
MEAN THAT. WHEN WE SAY THIRTY-TWO WE MEAN THREE TENS AND
TWO. IN THIS CODE THE 3 IN 32 REPRESENTS 3 ....'S
8
CORRECT

16

WHEN YOU USE BASE 8 CODE YOU MAKE AS MANY COMPLETE GROUPS
OF .... AS YOU CAN.
8
CORRECT

Frame #   Actual Text

17

WRITE A BASE 8 NUMERAL TO REPRESENT THE FOLLOWING TALLY.
/ /
26
THAT IS CORRECT

18

THE BASE 8 CODE NUMERAL 26 TELLS YOU THAT THERE WERE 2
GROUPS OF .....
10
NO, THERE WERE TWO GROUPS OF 8   X

19

IF WE WERE USING BASE FIVE CODE WE WOULD MAKE AS MANY
GROUPS OF .... AS WE COULD.
5
VERY GOOD, THAT IS CORRECT

20

WRITE A NUMERAL FOR THIS TALLY IN BASE 5 CODE.
/ /
41
YOU ARE CORRECT.

21

WRITE A NUMERAL FOR THIS TALLY IN BASE 5 CODE.
/ /
44
YOU ARE CORRECT

22

INSTEAD OF TALKING ABOUT BASE 5 CODE WE WILL JUST SAY
BASE 5. IF 42 REPRESENTS 4 X 5 + 2 WE ARE USING BASE .....
5
VERY GOOD.

23

IF 42 REPRESENTS 4 X 10 + 2 WE ARE USING BASE .....
10
THAT IS CORRECT.

24

IF 42 REPRESENTS 4 X 8 + 2 WE ARE USING BASE .....
8
BASE 8 IS CORRECT

25

IF WE ARE COUNTING IN BASE 5, 43 REPRESENTS 4 X .... + 3
5
YOU ARE CORRECT

26

IF WE ARE COUNTING IN BASE 8, 43 REPRESENTS 4 X ... + 3
8
THAT IS CORRECT

27

DO 43 IN BASE 5 AND 43 IN BASE 8 REPRESENT THE SAME THING?
ANSWER YES OR NO
YES
NO, THE ANSWER IS NO   X

28

IN ORDER TO TELL THE DIFFERENCE BETWEEN TWO NUMERALS WE NEED TO KNOW WHAT BASES ARE BEING USED. SUPPOSE YOU WERE WATCHING SOMEONE COUNTING SOME THINGS AND TO HELP HIMSELF HE WAS ARRANGING THEM LIKE THIS.

```
* * * * * * * * * *            * * *
* * * * * * * * * *
```

WHAT NUMBER BASE WOULD YOU GUESS HE WAS USING?
10
VERY GOOD

29

FOR THIS ARRANGEMENT,

```
* * * * * * * * * *      * * *
* * * * * * * * * *
```

HOW MANY COMPLETE GROUPS OF TEN COULD BE FORMED?
2
CORRECT

30

HOW MANY ARE LEFT OVER WHEN GROUPS OF TEN ARE MADE FROM THIS ARRANGEMENT?

```
* * * * * * * * * *     * * *
* * * * * * * * * *
```

3
YOU ARE CORRECT

31

A NUMBER OF THINGS IS REPRESENTED BY 2 X 10 + 3 WHICH IS WRITTEN IN BASE 10 AS .....
20
NO, IT IS WRITTEN AS 23 X

32

SUPPOSE THAT STARS WERE ARRANGED AS FOLLOWS,

```
* * * * * *        * * * * *
* * * * * *
* * * * * *
```

WHAT BASE DO YOU THINK THIS PERSON IS USING?
6
VERY GOOD

33

IT LOOKS LIKE BASE 6 IS BEING USED IN THIS ARRANGEMENT

```
* * * * * *        * * * * *
* * * * * *
* * * * * *
```

SINCE HE HAS ARRANGED AS MANY OF THE STARS AS POSSIBLE IN GROUPS OF .....
6
CORRECT

34

HOW MANY ARE LEFT OVER WHEN GROUPS OF 6 ARE MADE?

```
* * * * * *        * * * * *
* * * * * *
* * * * * *
```

5
GREAT

Frame # Actual Text

35

HOW MANY COMPLETE GROUPS OF 6 ARE THERE IN THIS
ARRANGEMENT?
* * * * * *   * * * * *
* * * * * *
* * * * * *
3
THAT IS CORRECT

36

A NUMBER OF THINGS IS REPRESENTED BY 3 X 6 + 5. A BASE SIX
PERSON WOULD WRITE - THERE ARE ..... THINGS.
23
NO, HE WOULD WRITE 35 X

37

FOR 35 IN BASE 6 THE 3 REPRESENTS 3 ....'S.
6
CORRECT

38

LOOK AT THE GROUP OF STARS NOT ARRANGED.
* *
SUPPOSE YOU WERE ACCUSTOM TO COUNTING IN BASE 5. THE
FIRST THING YOU WOULD DO WOULD BE TO MAKE AS MANY COMPLETE
GROUPS OF .... AS YOU COULD.
5
YOU ARE CORRECT

39

TO HELP YOU COUNT, MARK OFF THE STARS IN FIVES, LIKE THIS
* * * * */* * * * * */*   AND SO ON.
WITH THE FOLLOWING STARS,
* *
HOW MANY COMPLETE GROUPS OF FIVE CAN YOU MAKE?
4
CORRECT

40

HOW MANY ARE LEFT OVER WHEN COMPLETE GROUPS OF FIVE ARE
MADE FROM THIS COLLECTION OF STARS?
* *
4
NO, THERE ARE 3 X

41

A BASE FIVE PERSON MIGHT ARRANGE THE STARS LIKE THIS,
* * * * *   * * *
* * * * *
* * * * *
* * * * *
IN GROUPS OF 5 WITH 3 LEFT OVER.
HE WOULD WRITE - THERE ARE .... STARS
43
VERY GOOD

Frame # Actual Text

42

IN BASE 5 THE 4 IN 43 REPRESENTS 4 .... 'S.
5
CORRECT

43

HERE IS A GROUP OF STARS.
* * * * * * * * * * * * * * *
A BASE 7 PERSON WOULD WRITE - THERE ARE .... STARS
21
VERY GOOD

44

THE 2 IN 21 IN BASE 7 TELLS YOU THAT YOU WERE ABLE TO MAKE 2 GROUPS OF .....
7
CORRECT

45

HERE ARE SOME STARS.
* * * * * * * * * * * * * * *
WHAT IS THE BASE 8 NUMERAL FOR THE NUMBER OF STARS?
17
VERY GOOD

46

THE NUMERAL TO REPRESENT THE GROUP OF STARS,
* * * * * * * * * * * * * * *   IN BASE 8 IS 17 SINCE YOU CAN MAKE ONE COMPLETE GROUP OF 8 AND HAVE .... LEFT OVER.
7
CORRECT

47

17 IN BASE 8 AND 21 IN BASE 7 BOTH REPRESENT THE SAME NUMBER. DO 17 AND 21 NORMALLY REPRESENT THE SAME NUMBER? ANSWER YES OR NO.
NO
CORRECT

48

IT IS IMPORTANT TO KNOW WHAT BASE IS BEING USED.
WE WILL WORK IN BASE 5 AND SEE HOW THIS CHANGES OUR ARITHMETIC. WHEN WE COUNT IN BASE 5 WE MAKE AS MANY GROUPS OF .... AS WE CAN.
5
CORRECT

49

HERE ARE SOME STARS.
* * * * * * * * * * * * * *
WHAT IS THE BASE FIVE NUMERAL FOR THE NUMBER OF STARS?
24
VERY GOOD

50

COUNTING CAN BE ILLUSTRATED THIS WAY.
*   **   ***   ****   *****
YOU CAN WRITE EACH OR THESE AS BASE 5 NUMERALS. WHAT IS * * *   IN BASE 5 ?
3
VERY GOOD

```
51
    WHAT IS  * * * * *  IN BASE 5 ?
    1
    NO, THE ANSWER IS 10                                        X
52

    WHAT IS  *  IN BASE 5 ?
    1
    CORRECT
53
    OUR COUNTING SO FAR IN BASE 5 IS
    *   **   ***   ****   *****
    1        3            10
    THERE ARE TWO SPACES HERE .
    WHAT GOES IN THE FIRST ONE ?
    2
    CORRECT
54
    WHAT GOES IN THE SECOND SPACE FOR BASE 5 COUNTING?
    *   **   ***   ****   *****
    1        3            10
    4
    VERY GOOD
55
    WE HAVE,
    *                  1
    * *                2
    * * *              3
    * * * *            4
    * * * * *          10
    * * * * * *
    * * * * * * *
    * * * * * * * *
    * * * * * * * * *
    * * * * * * * * * *
    LET'S REPRESENT THE NUMBER OF STARS IN THE MISSING
    SPACES BY A BASE FIVE NUMERAL.  WHAT IS THE BASE FIVE
    NUMERAL FOR   * * * * * *
    11
    VERY GOOD
56
    WHAT IS THE BASE FIVE NUMERAL FOR THIS NUMBER OF STARS ?
    * * * * * * * *
    13
    CORRECT
57
    WHAT IS THE BASE FIVE NUMERAL FOR THIS NUMBER OF STARS ?
    * * * * * * * * * *
    20
    VERY GOOD
```

Frame # Actual Text

58

OUR COUNTING IN BASE FIVE IS
1 2 3 4 10 11 .. 13 .. 20
WHAT COMES AFTER THE 11? 11 IS READ AS ONE-ONE, NOT ELEVEN.
12
CORRECT

59

WHAT COMES AFTER 13 IN BASE FIVE COUNTING?
14
CORRECT

60

BASE 5 COUNTING LOOKS LIKE THIS.
1 2 3 4 10 11 12 13 14 20 ...
WHEN WE COUNT IN BASE 5 DO WE USE THE SYMBOL 6 ?
ANSWER YES OR NO .
NO
THAT IS CORRECT

61

WHEN WE COUNT IN BASE 5 DO WE USE THE SYMBOL 5 ?
ANSWER YES OR NO
NO
CORRECT

62

WHEN WE COUNT IN BASE 5 WE ONLY USE THE SYMBOLS
0,1,2,3, AND 4. IN BASE 5 WE ONLY USE THOSE SYMBOLS THAT
ARE LESS THAN .....
5
CORRECT

63

HERE IS A BASE 5 QUESTION 3 + 4 = ...
WHICH WE CAN WRITE AS
* * * + * * * * = * * * * * * *
3 + 4 = ...
WHAT IS THE SUM ?
REMEMBER, THIS IS BASE 5.
12
VERY GOOD

64

IN BASE 5,
* * * * * * * = * * * * */* *
WHICH WE WRITE AS 12.
IN BASE 5, 3 + 4 = 12
HERE IS ANOTHER QUESTION IN BASE 5.
* * + * * * * = * * * * * *
2 + 4 = ...
WHAT IS THE SUM IN BASE 5?
11
THAT IS CORRECT

65

IN BASE 5, 2 + 4 = 11
TRY THIS BASE 5 QUESTION .
DRAW STARS TO HELP YOU IF YOU LIKE.
1 + 1 = ...
2
CORRECT

66

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
1 + 2 = ...
3
CORRECT

67

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
1 + 3 = ...
4
THAT IS CORRECT

68

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
1 + 4 = ...
10
VERY GOOD

69

TO FIND THE SUM OF 1 + 4 WE CAN'T USE THE SYMBOL 5 IN BASE 5 CODE. OUR COUNTING WENT 1 2 3 4 10 11 ....
USING STARS, THE QUESTION 1 + 4 CAN BE WRITTEN,

```
* + * * * * = * * * * *
1 +    4    =     ...
```

WHAT IS * * * * * IN BASE 5 ?
10
CORRECT

70

WE HAVE,
1 + 1 = 2
1 + 2 = 3
1 + 3 = 4
1 + 4 = 10
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
2 + 1 = ...
3
CORRECT

71

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
2 + 2 = ...
4
CORRECT

72

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
2 + 3 = ...
10
CORRECT

73
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
2 + 4 = ...
11
CORRECT

74
WE HAVE,
2 + 1 = 3
2 + 2 = 4
2 + 3 = 10
2 + 4 = 11
NOW TRY THIS QUESTION, USING BASE 5.
3 + 1 = ...
4
CORRECT

75
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
3 + 2 = ...
10
CORRECT

76
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
3 + 3 = ...
11
CORRECT

77
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
4 + 1 = ...
10
CORRECT

78
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
4 + 2 = ...
11
CORRECT

79
FIND THE SUM OF THESE TWO NUMBERS IN BASE 5
4 + 4 = ...
13
VERY GOOD

80
WE CAN SUMMARIZE BASE 5 ADDITION FACTS IN A TABLE. IN FRONT OF YOU IS A TABLE OF BASE 5 ADDITION. TO SHOW HOW IT WORKS, LET'S FIND THE SUM OF 2 + 3. LOOK DOWN THE LEFT-HAND COLUMN TO 2, AND PUT YOUR FINGER THERE. KEEP THAT FINGER WHERE IT IS AND LOOK ACROSS THE TOP ROW TO 3 AND PUT ANOTHER FINGER THERE. MOVE THE 2 FINGER ACROSS, AND THE 3 FINGER DOWN, UNTIL THEY MEET, WHICH SHOULD BE AT 10. THIS TELLS YOU THAT 2 + 3 = 10
NOW USE THE TABLE TO FIND THE SUM,
2 + 4 = ...
11
VERY GOOD

81

USE THE TABLE IN FRONT OF YOU TO FIND THE SUM
OF THESE NUMBERS IN BASE 5
4 + 1 = ...
10
VERY GOOD

82

USE THE TABLE IN FRONT OF YOU TO FIND THE SUM
OF THESE NUMBERS IN BASE 5
3 + 3 = ...
11
VERY GOOD

83

USE THE TABLE IN FRONT OF YOU TO FIND THE SUM
OF THESE NUMBERS IN BASE 5
4 + 3 = ...
12
VERY GOOD

84

USE THE TABLE IN FRONT OF YOU TO FIND THE SUM
OF THESE NUMBERS IN BASE 5
1 + 3 = ...
4
VERY GOOD

85

THE TABLE IN FRONT OF YOU CAN HELP YOU DO HARD ADDITION
PROBLEMS IN BASE 5. USE THE TABLE WHENEVER YOU LIKE.
LOOK AT THIS BASE 5 ADDITION PROBLEM.

```
 41
+32
---
```

THE FIRST THING TO DO IS ADD 1 AND 2.
WHAT IS 1 + 2 IN BASE 5 ?
3
CORRECT

86

THE FIRST STEP IN ADDING 41 AND 32 IN BASE 5 IS

```
 41
+32
---
  3
```

NEXT WE ADD 4 AND 3. WHAT IS 4+3 IN BASE 5 ?
12
VERY GOOD

87

THE ANSWER TO THE BASE 5 ADDITION PROBLEM BELOW IS

```
 41
+32
---
123
```

IS THIS THE SAME ANSWER AS YOU WOULD GET IN BASE 10 ?
ANSWER YES OR NO
NO
YOU ARE CORRECT

88

YOU GET DIFFERENT SUMS IN BASE 5 THAN IN BASE 10 BECAUSE NUMERALS LIKE 41 MEAN DIFFERENT THINGS IN BASE 5 THAN IN BASE 10. IN BASE 5 THE 4 IN 41 REPRESENTS 4 ... 'S.

5

THAT IS CORRECT

89

IN BASE 10 THE 4 IN 41 REPRESENTS 4 ....'S

10

CORRECT

90

IN BASE 8 THE 4 IN 41 REPRESENTS 4 ...'S.

8

THAT IS CORRECT

91

HERE IS A BASE 5 PROBLEM.

```
 32
+22
---
```

WHAT IS THE FIRST THING TO DO ?

1. 3 + 2
2. 2 + 2

ANSWER 1 OR 2

2

YOU ARE CORRECT

92

WHEN PERFORMING COLUMN ADDITION,
YOU ALWAYS ADD THE RIGHT - HAND COLUMN FIRST.

```
 32
+22
---
```

WHAT IS 2 + 2 IN BASE 5 ?
YOU CAN USE THE BASE 5 ADDITION TABLE IN FRONT OF YOU.

4

THAT IS CORRECT

93

THE PROBLEM IN COLUMN ADDITION BEGINS AS FOLLOWS,

```
 32
+22
---
  4
```

THE FIRST STEP IS TO ADD 2 + 2 WHICH EQUALS 4.
THE NEXT STEP IS TO ADD 3 AND 2.
WHAT IS THIS SUM IN BASE 5 ?

10

CORRECT

94

THE ANSWER TO THE BASE 5 ADDITION PROBLEM IS
```
 32
+22
---
104
```
NOW TRY THIS BASE 5 PROBLEM. USE THE TABLE IN FRONT OF YOU WHENEVER YOU LIKE.
```
 21
+42
---
113
```
VERY GOOD

95

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
```
 40
+34
---
124
```
VERY GOOD

96

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
```
 43
+31
---
124
```
VERY GOOD

97

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
```
 32
+32
---
114
```
VERY GOOD

98

FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
```
 30
+20
---
100
```
VERY GOOD

99

THIS BASE 5 ADDITION PROBLEM NEEDS SOME CARE.
```
 23
+14
---
```
THE FIRST THING TO DO IS TO ADD 3 AND 4.
WHAT IS 3 + 4 IN BASE 5?
12
VERY GOOD

<u>Frame #</u>   <u>Actual Text</u>

```
100
    TO ADD THESE TWO NUMBERS IN BASE 5
     23
    +14
    ---
      2      YOU HAVE TO WRITE DOWN 2 IN THE ONES COLUMN AND
    CARRY 1 TO THE 5'S COLUMN AS IN ADDITION FOR BASE 10.
    WHAT IS THE SUM OF THE SECOND COLUMN WHEN 1 IS CARRIED
    OVER AS PART OF THE SUM.
    4
    VERY GOOD
101
    THE SUM OF 23 AND 14 IS
     23
    +14
    ---
     42
    HERE IS A PROBLEM IN WHICH YOU WILL HAVE TO DO
    SOME CARRYING.  IT IS A BASE 5 PROBLEM.
     13
    +24
    ---
    42
    VERY GOOD
102
    FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
     14
    +24
    ---
    43
    VERY GOOD
103
    FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
    14
    +2
    ---
    21
    VERY GOOD
104
    FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
     23
    +12
    ---
    40
    THAT IS CORRECT
105
    FIND THE SUM OF THESE TWO NUMBERS IN BASE 5.
     13
    +23
    ---
    41
    THAT IS CORRECT
```

```
106
    WHICH OF THESE IS THE SAME AS 2 X 41 ?
    1.  2 + 41
    2.  41 X 41
    3.  41 + 41
    ANSWER 1 OR 2 OR 3
    3
    THAT IS CORRECT
107
    THE MULTIPLICATION QUESTION
    41
    X2
    ---
    AND THE ADDITION QUESTION
     41
    +41
    ---
    REPRESENT THE SAME THING AND SO WILL HAVE THE SAME ANSWER.
    YOU CAN FIND THE ANSWER TO 41 X 2
    BY WORKING OUT
     41
    +41
    ---
    WHAT IS THE ANSWER TO THIS PROBLEM IN BASE 5.
    132
    THAT IS VERY GOOD
108
    HERE IS A BASE 5 MULTIPLICATION PROBLEM.
    32
    X2
    ---
    WRITE IT AS AN ADDITION PROBLEM  ON A PIECE OF PAPER IF
    YOU LIKE.  YOU HAVE A BASE 5 ADDITION TABLE IN FRONT OF
    YOU NOT A MULTIPLICATION TABLE, SO ADDITION IS PROBABLY
    EASIER FOR YOU.  WHAT IS THE ANSWER TO THE PROBLEM?
    114
    THAT IS VERY GOOD
109
    FIND THE PRODUCT OF THESE TWO NUMBERS IN BASE 5
    23
    X2
    ---
    101
    THAT IS CORRECT
110
    FIND THE PRODUCT OF THESE TWO NUMBERS IN BASE 5
    33
    X2
    --
    121
    THAT IS VERY GOOD
```

Frame # Actual Text

111

FIND THE PRODUCT OF THESE TWO NUMBERS IN BASE 5
24
X2
--
103
THAT IS VERY GOOD

112

SO NOW YOU KNOW HOW TO COUNT IN BASE 5 AND HOW TO DO SOME ADDITION AND MULTIPLICATION . THIS IS THE END OF THE LESSON. GO AND TELL THE TEACHER YOU HAVE FINISHED. GOODBYE.

APPENDIX II

ORDER OF FRAME PRESENTATION FOR THE SCRAMBLED SEQUENCE

PROGRAM I

97 27 60 51 84 102 34 105 7 63 49 17 96 93 46 32 95 58 87 54
29 37 103 14 42 79 30 50 25 8 20 109 76 21 52 28 19 1 47
55 2 81 18 24 106 83 82 73 36 15 99 111 43 38 48 91 6 5
107 92 26 66 104 74 68 101 41 3 40 78 108 56 4 69 70 44
80 9 65 72 86 85 10 39 11 89 45 57 67 100 62 13 59 33 23
75 22 110 94 61 12 90 16 53 98 71 77 88 31 64 35

PROGRAM II

50 13 41 18 90 84 30 91 94 74 101 59 97 29 7 73 78 65 11 33
95 98 55 54 44 102 36 110 35 4 85 69 2 47 67 34 57 38 40
3 63 75 104 26 100 24 25 106 48 92 86 71 58 6 62 49 72 32
80 77 53 42 46 31 81 96 10 66 28 87 8 89 14 105 12 82 27
5 108 16 64 52 109 88 79 45 15 76 107 99 1 21 56 60 23 17
39 9 61 83 22 19 37 68 103 93 70 51 20 43 111

PROGRAM III

104 32 56 36 35 85 9 14 12 47 87 55 2 77 54 66 102 103 53 49
18 58 71 1 74 110 33 84 83 19 23 100 46 25 78 61 13 22
75 96 72 17 26 97 93 76 40 4 64 38 45 82 43 73 90 106 65
44 67 59 88 62 105 42 29 60 50 8 37 51 31 41 108 30 111
11 68 39 92 34 94 95 80 101 79 107 81 6 86 10 109 52 24
16 15 21 3 70 27 63 69 91 5 57 20 7 98 28 99 89 48

PROGRAM IV

59 68 79 100 110 80 35 34 51 28 29 6 54 108 66 52 46 32 56
37 2 77 30 58 40 42 15 83 61 89 92 7 88 3 111 12 23 41
14 71 60 21 70 39 102 17 1 20 95 16 103 72 82 99 48 98
76 73 90 96 22 25 63 84 101 81 67 97 85 13 19 47 8 24
55 50 105 31 62 107 36 87 27 38 94 74 45 86 104 11 49 44
109 78 93 106 5 10 75 65 64 26 91 53 43 4 18 9 69 33 57

APPENDIX III

THE POSTTEST

NAME:

---

1. If 27 represents 2 x 9 + 7, what number base is being used?

---

2. Write a base 7 numeral to represent this number of stars.

* * * * * * * * * * * * * * * * * *

---

3. Write a base 6 numeral to represent this number of stars.

* *

* * * * * * *

---

4. Write a base 8 numeral to represent this number of squares.

□ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □

---

5. Represent this sum in base 5 arithmetic.

* * * * + * * * * * * * = * * * * * * * * * * *

________ + ______________ = ______________________

---

6. Represent this sum in base 4 arithmetic.

* * * * * + * * * * * * = * * * * * * * * * * *

__________ + ____________ = ______________________

---

7. Write the base 5 numerals from 1 to 20.

(both 1 and 20 are base 5 numerals)

All the questions on this page are base 5 questions.

You may use your base 5 addition table whenever you like.

8. Add in base 5. 10 42	15. Add in base 5. 321 240
9. Add in base 5. 13 14	16. Add in base 5. 24 33 42
10. Add in base 5. 32 24	17. Add in base 5. 432 324
11. Multiply in base 5. 32 x2	18. Multiply in base 5. 321 x 2
12. Multiply in base 5. 24 x2	19. Multiply in base 5. 234 x 2
13. Add in base 5. 21 31 40	20. Multiply in base 5. 21 x4
14. Add in base 5. 412 231	21. Multiply in base 5. 34 x3

22. Write the base 4 numerals from 1 to 12.
(both 1 and 12 are base 4 numerals)

23. Write the base 5 numerals from 32 to 44.
(both 32 and 44 are base 5 numerals)

The next six questions (numbers 24 to 29) are base 8 questions. Use the base 8 table provided whenever you like.

24. Add in base 8. 24 73 ___	27. Multiply in base 8. 63 x2 ___
25. Add in base 8. 36 24 ___	28. Multiply in base 8. 35 x2 ___
26. Add in base 8. 47 52 ___	29. Multiply in base 8. 57 x2 ___

30. If you were counting in base 6, what numerals would you use?

31. What base would a person be using if he wrote:
I have 14 toes?
(in fact he has the same number of toes as everyone else)

32. What base is this person counting in?
. . . . . 33, 34, 35, 36, 40, 41, ...

---

33. What base is being used here?

    4 + 3 = 10

---

34. Here is an addition problem: 34 + 62

    Could this be a base five sum? Why?

---

35. If Ann writes: "I have 18 dollars," when she is counting in base ten, then if she were using base five she would write: "I have ________ dollars."

---

36. Pete and Bill have the same number of books. Pete counts his in base five and writes that he has 43 books. Bill counts his in base ten and writes that he has _______ books.

---

37. What is the smallest possible base a person could be using if he wrote down the sum 35 + 23?

---

38. Here is part of a base four addition table. Fill in the spaces.

+	1	2	3
1			
2			
3			

---

39. Subtract in base 5.

$$\begin{array}{r} 33 \\ \underline{-4} \\ \underline{\quad} \end{array}$$

---

40. Subtract in base 5.

$$\begin{array}{r} 23 \\ \underline{-14} \\ \underline{\quad} \end{array}$$

---

41. Here is part of a base five multiplication table. Fill in the spaces.

X	1	2	3	4
1				
2				
3				
4				

42. If I have 23 dollars in base 6, how many do I have in base 5?

BASE FIVE ADDITION TABLE

+	1	2	3	4
1	2	3	4	10
2	3	4	10	11
3	4	10	11	12
4	10	11	12	13

BASE EIGHT ADDITION TABLE

+	1	2	3	4	5	6	7
1	2	3	4	5	6	7	10
2	3	4	5	6	7	10	11
3	4	5	6	7	10	11	12
4	5	6	7	10	11	12	13
5	6	7	10	11	12	13	14
6	7	10	11	12	13	14	15
7	10	11	12	13	14	15	16

APPENDIX IV

THE EXPERIMENTAL DATA

TABLE X

SCORES ON PROGRAM FACTS AND SKILLS FOR
THE LOGICAL SEQUENCE
HIGH I.Q.

SCORES FOR	STUDENT NUMBER								
EACH ITEM	1	2	3	4	5	6	7	8	9
1.	1	1	1	1	1	1	1	1	1
2.	1	1	1	1	1	0	1	1	1
3.	1	1	1	1	1	0	1	1	1
4.	1	1	1	1	1	0	1	1	1
5.	1	1	1	1	0	0	1	1	1
6.	1	1	1	0	0	0	1	0	1
7.	0	0	1	1	1	1	1	1	1
8.	1	1	1	1	1	1	1	1	1
9.	1	1	1	1	1	1	1	1	1
10.	1	1	1	1	1	1	0	1	0
11.	1	1	1	1	1	1	1	1	0
12.	1	1	0	1	1	0	1	1	0
TOTAL SCORE	11	11	11	11	10	6	11	11	9

TABLE XI

SCORES ON PROGRAM FACTS AND SKILLS FOR
THE LOGICAL SEQUENCE
LOW I.Q.

SCORES FOR	STUDENT NUMBER								
EACH ITEM	1	2	3	4	5	6	7	8	9
1.	0	0	1	0	1	1	0	1	1
2.	1	0	0	0	1	1	1	0	1
3.	1	0	0	0	1	1	0	1	1
4.	1	0	0	0	1	1	0	1	1
5.	1	0	1	0	0	0	0	1	1
6.	0	0	0	0	1	0	0	1	0
7.	0	1	1	0	0	1	0	0	1
8.	1	1	1	1	1	1	1	1	1
9.	1	1	1	1	1	1	0	1	1
10.	1	1	1	1	1	1	0	1	1
11.	0	0	0	1	1	1	0	1	1
12.	1	0	1	1	0	1	0	0	1
TOTAL SCORE	8	4	7	5	9	10	2	9	11

TABLE XII

SCORES ON PROGRAM FACTS AND SKILLS FOR
THE SCRAMBLED SEQUENCE
HIGH I.Q.

SCORES FOR EACH ITEM	STUDENT NUMBER 1	2	3	4	5	6	7	8	9
1.	1	1	1	1	1	1	1	1	1
2.	1	0	1	0	0	1	1	0	1
3.	1	0	1	0	0	1	1	0	1
4.	1	0	1	0	0	1	1	0	1
5.	1	0	0	0	0	1	0	0	0
6.	1	0	0	0	0	1	0	0	0
7.	1	1	1	1	0	1	1	0	1
8.	1	1	1	1	0	1	1	1	1
9.	1	0	1	1	1	1	1	0	1
10.	1	1	1	1	1	1	0	0	1
11.	1	1	0	1	0	1	0	0	0
12.	1	1	0	1	0	0	1	0	1
TOTAL SCORE	12	6	8	7	3	11	8	2	9

TABLE XIII

SCORES ON PROGRAM FACTS AND SKILLS FOR
THE SCRAMBLED SEQUENCE
LOW I.Q.

SCORES FOR	STUDENT NUMBER								
EACH ITEM	1	2	3	4	5	6	7	8	9
1.	0	0	0	1	1	1	1	0	0
2.	0	0	0	0	1	1	1	0	1
3.	0	0	0	0	1	1	1	1	1
4.	0	0	0	0	1	0	1	1	1
5.	0	0	0	0	1	1	0	0	0
6.	0	0	0	0	0	0	1	0	0
7.	0	0	0	0	1	0	1	0	1
8.	0	0	1	0	1	1	1	1	1
9.	0	1	1	1	1	1	1	1	1
10.	0	1	1	1	1	1	1	1	1
11.	0	0	1	1	1	1	1	1	1
12.	0	0	0	0	0	1	1	0	0
TOTAL SCORE	0	2	4	4	10	9	11	6	8

TABLE XIV

SCORES ON EXTENSION MATERIAL FOR
THE LOGICAL SEQUENCE
HIGH I.Q.

SCORES FOR EACH ITEM	STUDENT NUMBER 1	2	3	4	5	6	7	8	9
13.	1	1	1	1	1	1	1	1	1
14.	1	1	1	0	1	1	1	1	1
15.	1	1	1	1	1	1	1	1	1
16.	0	1	0	1	1	0	1	0	1
17.	1	1	1	1	1	1	1	1	1
18.	1	1	0	1	1	1	1	1	0
19.	1	0	1	1	1	0	1	1	0
20.	1	0	1	1	0	0	0	1	0
21.	0	0	1	1	0	0	0	0	0
22.	0	0	1	0	0	0	1	1	1
23.	1	0	0	1	1	0	1	1	1
24.	1	0	0	1	1	1	1	1	1
25.	1	1	1	1	1	1	1	1	1
26.	1	1	1	1	1	1	1	0	1
27.	1	0	1	1	1	1	1	1	0
28.	0	1	0	1	1	1	1	1	0
29.	0	1	1	0	1	1	1	1	0
30.	1	0	0	0	0	0	0	0	1
31.	0	0	1	1	1	0	1	0	1
32.	1	0	1	1	1	0	1	0	1
33.	0	0	1	1	0	0	1	1	1
34.	0	0	0	1	0	0	1	0	1
35.	0	0	1	0	1	0	1	1	1
36.	1	0	0	1	0	0	1	0	1
37.	1	0	0	1	0	0	1	0	0
38.	1	0	0	1	0	0	1	0	0
39.	1	0	0	1	0	0	1	0	0
40.	1	0	0	1	0	0	1	0	0
41.	0	0	1	0	0	0	1	0	1
42.	1	0	1	0	0	0	1	0	1
TOTAL SCORE	20	10	18	23	17	11	27	16	19

TABLE XV

SCORES ON EXTENSION MATERIAL FOR
THE LOGICAL SEQUENCE
LOW I.Q.

SCORES FOR	STUDENT NUMBER								
EACH ITEM	1	2	3	4	5	6	7	8	9
13.	1	0	1	1	1	1	1	0	1
14.	0	1	1	1	1	1	1	0	1
15.	1	1	1	1	1	1	1	1	1
16.	0	0	1	0	0	1	0	1	1
17.	1	0	1	0	1	1	1	1	1
18.	1	0	1	1	1	1	0	1	1
19.	1	0	0	1	0	1	0	0	1
20.	1	0	1	0	0	1	0	0	1
21.	0	0	0	0	0	0	0	0	1
22.	0	0	0	0	0	1	0	0	1
23.	1	0	0	0	0	1	0	0	1
24.	1	1	0	1	1	1	1	0	1
25.	1	1	0	1	0	1	1	1	1
26.	1	1	0	1	1	1	1	1	1
27.	1	0	0	1	1	1	0	0	1
28.	0	0	0	1	0	0	0	0	1
29.	0	0	0	1	1	0	0	0	1
30.	0	0	0	0	0	0	0	0	0
31.	0	0	0	0	0	0	0	0	1
32.	0	0	0	0	0	0	0	0	1
33.	1	0	0	1	0	0	0	1	1
34.	1	0	0	0	0	1	0	1	1
35.	1	0	0	0	1	1	0	0	1
36.	1	0	0	0	0	1	0	0	1
37.	1	0	0	0	0	0	0	0	1
38.	0	0	0	0	0	0	0	1	1
39.	0	0	1	0	0	0	0	0	0
40.	0	0	1	0	1	0	0	0	0
41.	0	0	0	0	0	0	0	0	1
42.	0	0	0	0	0	0	0	0	0
TOTAL SCORE	16	5	9	12	11	17	7	9	26

TABLE XVI

SCORES ON EXTENSION MATERIAL FOR
THE SCRAMBLED SEQUENCE
HIGH I.Q.

SCORES FOR EACH ITEM	STUDENT NUMBER 1	2	3	4	5	6	7	8	9
13.	1	1	1	1	0	1	1	1	1
14.	1	1	0	1	0	1	1	0	1
15.	1	1	1	1	1	0	1	0	1
16.	1	1	0	1	0	0	0	0	1
17.	1	1	0	1	1	1	1	0	1
18.	1	1	0	1	1	1	1	0	1
19.	1	1	0	1	0	0	0	0	1
20.	1	0	1	1	0	1	1	0	1
21.	1	0	1	0	0	0	0	0	0
22.	0	0	1	0	0	1	1	0	1
23.	1	1	1	1	0	1	1	0	1
24.	1	0	1	1	1	0	1	0	1
25.	1	0	0	1	0	0	1	0	1
26.	1	0	1	0	1	0	1	0	1
27.	1	0	0	0	1	0	1	0	1
28.	1	0	0	1	1	0	1	0	1
29.	1	0	0	0	1	0	1	0	1
30.	0	0	0	0	0	0	0	0	0
31.	0	0	0	0	1	0	1	0	1
32.	1	1	1	0	0	1	1	1	1
33.	1	0	1	0	0	0	1	0	0
34.	0	0	1	1	0	0	0	0	0
35.	1	0	0	0	0	1	1	0	0
36.	1	0	1	0	0	1	1	0	0
37.	0	0	1	0	0	0	1	0	0
38.	1	0	0	0	0	0	1	0	1
39.	1	0	0	1	0	0	1	0	0
40.	1	0	0	0	0	0	0	0	0
41.	1	0	0	0	0	0	0	0	0
42.	0	0	0	0	0	0	0	0	0
TOTAL SCORE	24	9	13	14	9	10	22	2	19

TABLE XVII

SCORES ON EXTENSION MATERIAL FOR
THE SCRAMBLED SEQUENCE
LOW I.Q.

SCORES FOR EACH ITEM	STUDENT NUMBER 1	2	3	4	5	6	7	8	9
13.	0	0	1	1	1	1	1	0	0
14.	0	1	1	0	1	0	1	1	0
15.	0	1	1	0	1	1	1	1	0
16.	0	0	0	1	1	1	1	0	0
17.	0	1	1	0	1	0	0	1	0
18.	1	0	0	1	1	1	1	1	1
19.	0	0	0	0	1	1	1	0	0
20.	1	0	0	0	1	0	1	0	0
21.	0	0	0	0	1	0	1	0	0
22.	0	0	0	0	0	0	1	0	1
23.	0	0	0	0	1	0	1	0	1
24.	0	1	1	0	0	1	0	1	1
25.	0	1	1	0	0	1	0	1	1
26.	0	1	1	0	0	1	1	1	1
27.	0	0	1	0	0	1	1	1	1
28.	0	0	1	1	0	1	0	1	1
29.	0	0	1	0	0	1	0	1	1
30.	0	0	0	0	0	0	1	0	0
31.	0	1	0	0	0	0	1	0	0
32.	1	1	0	0	0	0	1	0	1
33.	1	0	0	0	0	1	0	0	0
34.	0	0	1	0	0	1	1	0	0
35.	0	0	0	0	1	1	1	0	0
36.	0	0	0	0	0	1	1	0	0
37.	0	0	0	0	0	1	1	0	0
38.	0	0	0	0	0	0	0	0	1
39.	0	0	0	0	0	1	0	0	0
40.	0	0	0	0	0	1	0	0	0
41.	0	0	0	0	0	0	0	0	0
42.	0	0	0	0	0	1	0	0	0
TOTAL SCORE	4	8	11	4	11	19	19	10	11

TABLE XVIII

PROGRAM ERRORS FOR THE LOGICAL SEQUENCE

HIGH I.Q.		LOW I.Q.	
STUDENT NUMBER	NUMBER OF ERRORS	STUDENT NUMBER	NUMBER OF ERRORS
1.	7	1.	16
2.	11	2.	25
3.	15	3.	34
4.	18	4.	31
5.	23	5.	29
6.	25	6.	4
7.	2	7.	43
8.	9	8.	19
9.	13	9.	8

TABLE XIX

PROGRAM ERRORS FOR THE SCRAMBLED SEQUENCE

HIGH I.Q.		LOW I.Q.	
STUDENT NUMBER	NUMBER OF ERRORS	STUDENT NUMBER	NUMBER OF ERRORS
1.	10	1.	47
2.	46	2.	32
3.	25	3.	54
4.	20	4.	27
5.	30	5.	33
6.	33	6.	40
7.	23	7.	18
8.	47	8.	46
9.	26	9.	38

TABLE XX

TIME TAKEN TO COMPLETE THE LOGICAL SEQUENCE

HIGH I.Q.		LOW I.Q.	
STUDENT NUMBER	TIME TAKEN (MINUTES)	STUDENT NUMBER	TIME TAKEN (MINUTES)
1.	65	1.	70
2.	72	2.	73
3.	60	3.	75
4.	65	4.	81
5.	70	5.	75
6.	63	6.	78
7.	60	7.	68
8.	75	8.	75
9.	40	9.	68

TABLE XXI

TIME TAKEN TO COMPLETE THE SCRAMBLED SEQUENCE

HIGH I.Q.		LOW I.Q.	
STUDENT NUMBER	TIME TAKEN (MINUTES)	STUDENT NUMBER	TIME TAKEN (MINUTES)
1.	65	1.	80
2.	63	2.	78
3.	63	3.	75
4.	67	4.	70
5.	82	5.	75
6.	70	6.	75
7.	64	7.	78
8.	73	8.	80
9.	70	9.	98

ADDITIONS