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ABSTRACT

A study was made of the effect of various learner and task characteristics on learning from scrambled frames in an instructional program. The independent variables were: sequence (scrambled vs. logical), grade, sequence length, criterion test complexity, sex, IQ, mathematics achievement, and reading comprehension. The dependent variables were: time in acquisition, errors in acquisition, immediate posttest scores, and retention test scores. The objective of the program was to teach how to compute line slopes, and the learning task was empirically shown to be linear. Multi-factor analyses of variance were performed on numerous combinations of variables. Grade level, mathematics achievement, and test complexity did not interact with sequence, but reading, sex, IQ, and sequence length did. Differences were observed in errors and time in acquisition, but not in performance on the criterion tests. The competence tests used are discussed in the appendix. References are given. (Author/MF)

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THE EFFECT OF LEARNER AND TASK CHARACTERISTICS ON LEARNING IN SCRAMBLED ITEM SEQUENCES IN PROGRAMMED INSTRUCTION

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Purpose of the Study

One of the major principles of instructional programming is that each item must be constructed in such a way as to promote positive transfer to the succeeding item. A number of studies (Gavurin and Donahue, 1961; Roe, 1962; Roe, Case and Roe, 1962; Levin and Baker, 1963; Hamilton, 1964; Payne, Krathwohl and Gordon, 1967; Niedermeyer, Brown and Sulzen, 1969; Brown, 1970) have tested this principle by examining the effects of learning in programs in which the instructional frames have been deliberately scrambled. These studies generally concluded that item scrambling did not harm, and possibly even helped learning.

Except for three studies which looked at the effects of sequencing under conditions of mathematics aptitude, IQ or response mode, the studies were not designed to converge on the specific causes of the differences in learning when and if differences appeared.

It was the purpose of the present study to examine the effect that various learner and task characteristics might have on learning in scrambled item sequences.

Methodology

In attempting to discover the conditions under which scrambled sequences affect learning, the following independent variables were manipulated.

1. Sequence: logical and scrambled
2. Grade: 6, 7 and 8
3. Sequence Length: 9, 17 and 70 frames
4. Criterion Test Complexity: comprehension, application and analysis

items.

5. Sex: male and female
6. IQ: low, middle and high (72 to 95, 96 to 105, 106 to 143 respectively)
7. Mathematics Achievement: low, middle and high (-3.4 to -.8, -.7 to +.7, +.8 to +4.2 grade equivalents respectively)
8. Reading Comprehension: low, middle and high (-3.1 to -.8, -.7 to +.7, +.8 to +4.5 grade equivalents respectively)

The following four dependent variables were used as criteria of learning.

1. Time to complete sequences
2. Errors made in sequences
3. Immediate posttest scores
4. Retention test scores (administered 14 days after the treatments)

The instructional objective of the program was to teach learners in Grades 6 to 8 how to compute line slopes. A previous study (Olsen, 1968) had empirically determined that the learning tasks of the program were linearly related.

The program was in booklet form, with the correct responses appearing on the back of each page. Linear programming techniques were used in constructing the basic program, and considerable attention was given to keeping the learners actively engaged in writing and drawing. Each frame was constructed as a discrete learning experience, and inter-frame dependency was avoided.

In order to determine the learning gains attributable to the basic program, the Solomon Four-Group Design was used for factoring out the effects of pretesting. It was determined that the program increased the competence of the subjects in each of Grades 6, 7 and 8 to at least the $p < .0005$ significance level. The mean competence gains amounted to 42%, 73%, and 44% within Grades 6, 7 and 8 respectively.

The total program was composed of three sections of different lengths. The item scrambling was carried out by randomly ordering the individual items within each of the three sections.

The immediate posttest and retention test contained problems at different levels of complexity in order to determine if the subjects under the scrambled condition could solve problems as well as the subjects under the logical condition when it came to problems at different levels of complexity (Appendix A).

Multi-factor analyses of variance were performed on a large number of combinations of the independent and dependent variables in order to examine the interactive effects of the sequences and the various learner, task, and criterion test characteristics.

Data Sources

The subjects were chosen from Grades 6, 7 and 8 in two rural-suburban school districts. The subjects' IQ scores ranged from 72 to 143, with a mean of 107.6. Their mathematics achievement scores ranged from 3.4 grade equivalents below to 4.2 grade equivalents above their actual grade location, with a mean of +.6. Their reading comprehension scores ranged from 3.1 grade equivalents below to 4.5 grade equivalents above their actual grade location, with a mean of +.7. There were 327 subjects in the total sample.

Findings

Regardless of the combinations of independent variables in interaction with sequence, the only meaningful significant differences that occurred regarding sequence were the following (Appendix B).

1. When the subjects were working in the longest sequence in the program, the middle reading subjects receiving the scrambled treatment made significantly ($p < .001$) more errors in the program than the middle reading subjects receiving the logical treatment.
2. When the subjects were working in the longest sequence in the program, the males receiving the scrambled treatment took significantly ($p < .05$) more time to advance through the program than the males receiving the logical treatment. Within the total group receiving the scrambled treatment, the males took significantly ($p < .05$) more time to complete the program than the females.
3. When the subjects were working in the longest sequence in the program, the middle IQ subjects receiving the scrambled treatment took significantly ($p < .01$) more time to advance through the program than the middle IQ subjects receiving the logical treatment. Within the total group receiving the scrambled treatment, the middle and high IQ groups both took significantly ($p < .001$ in both cases) more time to complete the program than the low IQ group.

Grade level, mathematics achievement and criterion test complexity did not significantly interact with sequence in any way, but reading comprehension, sex, IQ and sequence length significantly affected the number of errors made or the amount of time spent in the program.

Although the middle reading comprehension, middle IQ, and male subjects made more errors or took more time in completing the program under the scrambled condition, they scored as highly on the posttest and retention tests as their counterparts under the logical condition.

Conclusions

Mathematics was chosen as the learning content of the experiment because it is generally considered to possess a more definite structure than other school learning areas such as history, English, geography, and so on. It was felt that if scrambled learnings have significant effects on the extent to which individuals learn, then these effects would be likely to be found in the study of mathematical learning tasks. Of eight previous item sequencing studies, six used mathematical tasks, one used a task in psychological terminology, and one used a task in the recognition of music symbols. Significant differences were found only in the studies using mathematics sequences.

It is thus felt that the statistically nonsignificant findings of the study generalize to areas of learning which possess structures of less rigidity than mathematics. That is, if item scrambling does not affect learning in mathematics, then it also will not affect learning in content areas of less structural rigidity.

Likewise, the statistically significant findings of the study generalize to learning in content areas which have structures similar to that of mathematics, or which have structures of greater rigidity, if such exist.

Three characteristics that were previously studied in interaction with sequence were mathematics aptitude, IQ, and response mode. But for the most part, the previous studies were not designed to converge upon the causes of learning differences when and if differences appeared. The present study manipulated a large number of variables in an attempt to determine the effects of various learner and task characteristics on learning in scrambled item sequences. If item scrambling has seriously detrimental effects on learning, then this study should have identified the causes of some of them.

The findings led to the following conclusions.

1. The linearity of the underlying structure of the learning task does not appear to be an important factor in affecting learning in scrambled item sequences.
2. The effects of item scrambling are the same at different grade levels, provided that the instructional program is constructed for the grade level concerned.
3. The usual predictors of mathematical performance such as IQ, mathematics ability, and mathematics achievement are not useful in predicting how subjects will perform in scrambled mathematics programs.
4. The scrambling of instructional programs does not prevent subjects from learning either simple or complex skills.
5. Although boys subsequently perform as highly as girls on posttests and retention tests, and possess the same mastery of the skills being taught, they require more time than girls to learn from scrambled item sequences.

6. Although subjects with different IQ's subsequently perform equally well on posttests and retention tests, and possess the same mastery of the skills being taught, subjects with average IQ's require more time than subjects with lower or higher IQ's to learn from scrambled item sequences.
7. Although subjects at different reading comprehension levels subsequently perform equally well on posttests and retention tests, and possess the same mastery of the skills being taught, subjects at average reading comprehension levels make more errors while learning from scrambled item sequences than subjects at lower or higher reading comprehension levels.
8. Differences in learning from scrambled item sequences are more likely to be detected in longer learning sequences than in shorter ones. (The previous studies did not vary sequence length, and one study used a sequence which was only 10 frames in length.)
9. When learning sequences are scrambled, the results are more likely to be detrimental than helpful to learning. (Some of the previous studies suggested that item scrambling helped learning rather than hindered it.)
10. Skinner's principle of careful sequencing is supported when it comes to time and errors in learning.
11. Gagné's theory of learning hierarchies is supported when it comes to time and errors in learning.
12. When item scrambling does produce detrimental effects to learning, these effects are more relative to the efficiency of instruction and learning than to the amount or type of learning that is involved.

Speculation.--In post-treatment interviews the subjects receiving the scrambled sequence treatments commented as favorably on the program as the subjects receiving the logical sequence treatments. The scrambled sequence group did not notice that the learnings were scrambled.

It appears that the sequencing studies have demonstrated one of the facts of life--that most of what we learn comes to us in disorganized lots. This being the case, the human organism has had sufficient practice in naturally disorganized learning to cope with artificially disorganized learning.

Implications

The study has a number of implications for both researchers and practitioners.

1. In research in sequence theory, longer rather than shorter sequences should be used if significant effects are to be discovered.
2. It may be that item sequencing has important learning effects which have not yet been discovered. It was found that subjects in the scrambled sequence groups needed more time to complete the retention test, although they did not need more time to complete the immediate posttest. This may imply that long-term retention is not achieved as well by subjects learning in scrambled sequences. Additional sequence research needs to be done in the affective and psychomotor areas of learning as well.
3. The findings of the study partially support the proposition that subjects who make errors while learning do not learn as well as

subjects who do not make errors while learning. The subjects making more errors went through the program more slowly, but they performed as well on the competence tests. Perhaps time in acquisition is the major consequence of error-making while learning. (The middle reading and middle IQ subjects were largely the same persons. They made more errors and needed more time in completing the scrambled program, but they performed as well as the logical treatment subjects on the competence tests.)

4. Levin and Baker scrambled the item sequence in a program of questionable quality. They suggested that a more effective program would probably have been disrupted more by item scrambling than a less effective one. The program used in the present study was of good quality, but it did not seem to be seriously damaged by item scrambling. This may suggest that the teaching ability of a program is not what causes criterion test differences in scrambled learning. This possibility needs to be further studied.

5. There is a possibility that the item scrambling spread out the different tasks so that the learning took place by wholes instead of by parts, and that the subjects somehow learned the component tasks all at the same time. This possibility needs to be further explored.

6. The conclusions suggest that the form of the content being taught may be less crucial to learning than the programming method by which it is taught. Repetition may reduce the harmful effects of occasional missequencing. It may be that if one cannot construct a

logical sequence, then repetitive exposure to the concepts of the content may compensate for it. Another tactic may be to construct frames which are as discrete as possible so as to avoid undue inter-frame dependency. These possibilities need to be studied further.

7. The results of the study indicated that boys and subjects with average IQ's require more time when learning from scrambled sequences. Each of these groups represents at least one-half of the population. If instructional program builders hope to individualize instruction for these two groups, they must see that instructional frames are carefully sequenced so as to provide maximum positive transfer from one frame to the next.

A need for more learning time by boys and by learners with average IQ's appears to be the most significant result of having nonlogical frame sequences in instructional programs. When item scrambling does produce detrimental effects in learning, these effects are more relative to the efficiency of instruction and learning than to the type or amount of learning produced by the program. This inefficiency can be a crucial matter in learning situations in which time is important. In cases in which the time required for learning is not important, however, the sequence in which individual frames and component learning tasks are arranged may not be so significant if: 1) the items in the program are constructed as discrete learning sets, 2) the concepts being programmed are used repetitively in several different situations, and 3) the learner is kept quite actively involved while he is advancing through the program.

REFERENCES

Bloom, Benjamin S. (Ed.) Taxonomy of Educational Objectives: Handbook I: Cognitive Domain. New York: Longmans, Green and Co., 1956.

Brown, Jerry L. "Effects of Logical and Scrambled Sequences in Mathematical Materials on Learning with Programmed Instruction Materials." Journal of Educational Psychology, 1970, 61, 41-45.

Gavurin, Edward I. and Donahue, Virginia M. "Logical Sequence and Random Sequence." Automated Teaching Bulletin, 1961, 1, 3-9.

Hamilton, Nancy R. "Effects of Logical Versus Random Sequencing of Items in an Autoinstructional Program under Two Conditions of Covert Response." Journal of Educational Psychology, 1964, 55, 258-266.

Levin, Gerald R. and Baker, Bruce L. "Item Scrambling in a Self-instructional Program." Journal of Educational Psychology, 1963, 54, 138-143.

Niedermeyer, Fred, Brown, Jerry and Sulzen, Bob. "Learning and Varying Sequences of Ninth-Grade Mathematics Materials." Journal of Experimental Education, 1969, 37, 61-66.

Olsen, Glenn W. "The Development and Analysis of a Hierarchy of Learning Tasks Involved in the Concept of Slope." Unpublished doctoral dissertation, Cornell University, 1968.

Payne, David A., Krathwohl, David R. and Gordon, John. "The Effect of Sequence on Programmed Instruction." American Educational Research Journal, 1967, 4. 125-132.

Roe, Arnold. "A Comparison of Branching Methods for Programmed Learning." Journal of Educational Research, 1962, 55, 407-416.

Roe, K. Vlachouli, Case, H. W. and Roe, Arnold. "Scrambled Versus Ordered Sequence in Autoinstructional Programs." Journal of Educational Psychology, 1962, 53, 101-104.

APPENDIX A

THE COMPETENCE TESTS

The competence tests measured skills at the comprehension, application and analysis levels (Bloom, 1956). Considerable care was given to the construction of the test items such that the instructional program did not explicitely "teach the answers" to the competence test questions. For example, the program taught the subjects how to compute slopes of lines when two coordinates appear on a line, and when the line is on a graph. One type of test item at the analysis level required that the subjects compute a slope when the coordinates of two points are given, but when no graph is shown and no visible line is given.

The tests measured whether the subjects could:

1. Identify the meaning of the terms "parallel" and "nonparallel." (comprehension)
2. Identify nonparallel lines on a graph in the case in which the lines intersect within the graph. (application)
3. Identify nonparallel lines on a graph in the case in which the lines would intersect outside of the graph if they were extended far enough. (analysis)
4. Identify lines for which slopes can be computed. (comprehension)
5. Compute the slope of a line, given the line on a graph and given two identified coordinates on the line. (application)
6. Compute the slope of a line by using two grid intersections through

which the line passes. (analysis)

7. Identify pairs of parallel lines, given a number of lines which have their slopes identified. (Comprehension)
8. Compute the slopes of two lines and identify whether the lines are parallel or not. (application)
9. Compute the slope of a line when given only two sets of coordinate pairs through which the line passes, when none of the given information appears on a graph, and when the line is not visibly indicated. (analysis)

The KR-20 reliability coefficient of each of the two competence tests was at least .84 for the complete test.

Each competence test was composed of three subtests. Each subtest contained nine test items, all of which measured the same type of complexity. The KR-20 reliability coefficients of each of these subtests is shown in the following table.

The KR-20 Reliability of the Subtests of Complexity

Subtest of Complexity	Immediate Posttest	Retention test
Comprehension	.72	.71
Application	.69	.75
Analysis	.73	.79

N = 113 subjects taking each subtest

APPENDIX B

Significant Differences Found in Which Sequence Was a Factor

Dependent Variable	Performance of the Treatment Groups	p
Errors in total program	Total Group, Logical < Total Group, Scrambled	< .03
Errors in total program	Middle Reading S's, Logical < Middle Reading S's, Scrambled	< .001
Errors in Sequence 70[a]	Total Group, Logical < Total Group, Scrambled	< .001
Errors in Sequence 70[a]	Middle Reading S's, Logical < Middle Reading S's, Scrambled	< .001
Time in Sequence 70[a]	Male, Logical < Male, Scrambled	< .05
Time in Sequence 70[a]	Female, Scrambled < Male, Scrambled	< .05

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APPENDIX B—Continued

Time in Sequence 70[a]	Middle IQ S's, Logical	<	Middle IQ S's, Scrambled	<	.01
Time in Sequence 70[a]	Low IQ S's, Scrambled	<	Middle IQ S's, Scrambled	<	.001
Time in Sequence 70[a]	Low IQ S's, Scrambled	<	High IQ S's, Scrambled	<	.001

[a] Sequence 9 contained 9 frames, Sequence 17 contained 17 frames, and Sequence 70 contained 70 frames. There were no significant differences attributable to the two shorter sequences.