The effects of varying the sequence of frames in a self-instructional program on the instructional outcomes of achievement, interest in learning, and attitudes toward programed instruction were investigated. Thirty-nine 6th grade Spanish classes were randomly assigned to a program with an orderly progression or a scrambled order of frames. The students worked on the program for 30 minutes each week without any teacher-directed instruction. For none of the three outcomes did the mean levels differ significantly after one semester of instruction. In each group a high relationship was found between aptitude and achievement and between initial attitudes and interest in learning. Attitudes toward programed instruction were not consistently related to any other variables. The conclusion was that small variations in sequence exert little effect on outcomes.

(KB)
THE EFFECTS OF VARIATIONS IN A SELF-INSTRUCTIONAL PROGRAM ON INSTRUCTIONAL OUTCOMES

Milton H. Maier
and
Paul I. Jacobs

Educational Testing Service
Princeton, New Jersey
June 1965
THE EFFECTS OF VARIATIONS IN A SELF-INSTRUCTIONAL PROGRAM
ON INSTRUCTIONAL OUTCOMES

Abstract

The effects of varying the sequence of frames in a self-instructional program on the instructional outcomes of achievement, interest in learning, and attitudes toward programed instruction were investigated. Thirty-nine sixth-grade Spanish classes were randomly assigned to a program with an orderly progression or a scrambled order of frames. The students worked on the program for 30 minutes each week without any teacher-directed instruction. For none of the three outcomes did the mean levels differ significantly after one semester of instruction. In each group a high relationship was found between aptitude and achievement and between initial attitudes and interest in learning. Attitudes toward programed instruction were not consistently related to any other variables. The conclusion was that small variations in sequence exert little effect on outcomes.
THE EFFECTS OF VARIATIONS IN A SELF-INSTRUCTIONAL PROGRAM ON INSTRUCTIONAL OUTCOMES

One of the current controversies in programmed instruction is the identification of variables that account for learning. Cook and Mechner (1962), for example, cite the following "elements combined by programmed instruction to produce optimal learning":

(a) Active response by the learner;
(b) Small steps in which careful control of stimuli produces gradual increments in mastery of the subject;
(c) Immediate feedback for each response;
(d) Self-pacing;
(e) Low error-rate, which is a consequence of the preceding four principles.

They go on to write that "error-free learning is not only simpler, but its effects improve morale, motivation, and retention" (p. 5). These authors imply that the absence of the five principles they cite will result in lower levels of both cognitive and noncognitive outcomes.

The AERA-APA-DAVI Joint Committee on Programed Instruction and Teaching Machines (1963), on the other hand, has stated: "At present, the scientific evidence is not considered sufficient to . . . justify recommendation that adherence to specific rules of program construction be used as a basis for program evaluation. External evidence is recommended as the main basis for the evaluation of program effectiveness."

Both positions cited here accept the behavior of the learners as the criterion by which to evaluate a program, but they differ on whether the program's internal characteristics can predict this behavior.
The available empirical evidence tends to support the position of the Joint Committee. Studies which have measured the outcome of achievement (e.g., Ashbaugh, 1964; Coulson & Silberman, 1960; Evans, Glaser, & Homme, 1960; Goldbeck & Campbell, 1962; Jacobs & Kulkarni, 1963; Levin & Baker, 1963; Moore & Smith, 1964; Roe, Case, & Roe, 1962), have found only minor or non-significant effects by varying the type of response (overt vs. covert) and sequence of the frames (orderly vs. scrambled).

The present study included the noncognitive outcomes of interest in learning and attitudes toward programmed instruction, as well as the cognitive outcome of achievement in assessing the effects of frame sequence in a program. The study also employed input characteristics in a dual role: first, as predictors that may account for the differences among the classes in a way that is meaningful to educators; and second, as covariance control variables that may increase the statistical precision of the experimental design.

Method

Subjects. The subjects were 824 students in 39 sixth-grade classes from the Denver Public Schools, Denver, Colorado.

Programs. A linear self-instructional program of 2016 frames, with a low error rate (5.7%) and a logical sequence, was developed to teach Spanish reading and writing to sixth-grade classes. The programming principles formulated by Skinner (1960) were carefully followed; first the behavioral objectives were specified in advance, then the frames were written, tried out, and revised until the learners performed satisfactorily. Because of the low error rate and the orderly progression of the frames, this version is
called the small-step version. The program was tried out in several schools prior to the present evaluation (Barcus, Hayman, & Johnson, 1961).

The sequence of frames of the small-step version was altered to produce a scrambled version. The alterations were not random; instead the frames within a unit were changed on an intuitive basis to break up the repetitiveness within each unit. The scrambled version was thus intended to be effective in producing learning and in stimulating interest. Its error rate of 7.1% was significantly higher (.01 level) than that for the small-step version (Hayman & Johnson, 1963).

Procedure. The program versions were randomly assigned to classes, with the restriction that the scrambled version be assigned to 22 classes in order to use up the existing supply of programs.

The classes worked on the programs for half an hour each Wednesday for one semester. No homework assignments or other instruction in Spanish reading and writing were given. The teachers, who were told not to answer any questions about Spanish, served only to maintain classroom order and to help with the mechanics of the program. Most teachers, in fact, did not know any Spanish.

The students also learned Spanish listening and speaking skills on Tuesdays and Thursdays, via televised and teacher-directed instruction. They had previously studied Spanish listening and speaking in the fifth grade, but had no prior instruction in Spanish reading and writing.

Input measures. The Kuhlman-Anderson Intelligence Test was used as the measure of academic aptitude; these scores were available from the school records. Initial attitudes toward Spanish (Preattitudes) were measured by the four-item inventory reproduced in Appendix A.
Outcome measures. Three kinds of instructional outcomes were used to evaluate the programs: (1) Achievement, (2) Attitudes toward Programmed Instruction, and (3) Interest in Spanish. The Sixth Grade Spanish, Reading and Writing Test (Follett Publishing Co., 1964) was used to measure achievement at the end of the first semester. The test, which was used with classes taught by a variety of other methods as well as by the program alone, had a split-half reliability of .94 (Hayman & Johnson, 1963).

Attitudes toward Programmed Instruction were measured by asking the students whether they preferred to learn various courses by a program alone, by a teacher alone, or by a combination of teacher plus program (items 2, 3, and 4 in Appendix B). The scoring of each item was dichotomized; a plus one was assigned to the alternative of learning by a program alone, and a zero was assigned to the other two alternatives. A high score reflected a desire to learn the courses by a program alone; a low score reflected a desire for teacher-directed instruction, either alone or in combination with a program. The internal consistency reliability of the attitude score was .60.

Interest in Spanish was measured by asking the student how frequently and for how many years he would like to study a foreign language, how much he enjoyed Spanish, and how often he read and conversed in Spanish on his own outside of school assignments (items 5-17 in Appendix B). The internal consistency reliability of the interest score was .86.

Results

Analyses of covariance were used to compare the effects of the program versions on the outcomes of Achievement (with Academic Aptitude as the control variable) and Interest in Spanish (with Preattitudes as the control
Because no input measure was consistently correlated with the Attitude toward Programed Instruction score, the single classification analysis of variance was used with this outcome. The class, and not the individual student, was the sampling unit, and therefore the class mean served as the unit of observation in the analyses.

The results of the analyses of covariance and variance are shown in Table 1. The two versions of the program did not differ significantly in their effects on any of the three outcomes. During the one semester of instruction, the sequence of the frames did not exert a substantial effect on class learning, interests, or attitudes.

The input characteristics of the class were substantially related to the outcomes of Achievement and Interest in Spanish. As shown in Table 2, the correlation of Aptitude with Achievement was high in both groups, .70 for the classes taught by the small-step version and .82 for the classes taught by the scrambled version. The correlation of Preattitudes with Interest in Spanish was almost as high, .50 and .71, respectively. The Attitudes toward Programed Instruction score was not correlated with Preattitudes for either version; it correlated positively with both Aptitude and Achievement for the small-step version, but negatively with them for the scrambled version. These correlations may be a result of chance rather than of systematic effects of the program version.
Contrary to what may be expected from the principles of program development as stated by Cook and Mechmer (1962), the variations in the program had little effect on the outcomes, both cognitive and noncognitive. The results of this study are consistent with much previous research and with the recommendations of the AERA-APA-DAVI Joint Committee on Programed Instruction and Teaching Machines (1963).

Both versions of the program tended to build upon the initial abilities and attitudes of the classes. Classes with high aptitude usually learned the most, and classes with the most favorable initial attitudes tended to have the highest level of interests at the end of the semester. Differences in outcomes were predictable by differences in input, but not by differences in the kind of program used for instruction.

In a larger study the small-step version used in combination with a trained Spanish teacher produced significantly more achievement than the program alone (Maier & Jacobs, 1964). This study also found that interest in learning was enhanced (a) by using the program as homework instead of classwork, and (b) by using the program with teacher-directed instruction plus making available a special corner of the classroom containing electronic aids, reading materials, and cultural artifacts (Hayman & Johnson, 1964). It appears that the level of outcomes, when not affected by differences in the program itself, may be affected by how the program is used.

One conclusion suggested by this and other research is that the effectiveness of a program may be relatively insensitive to changes within the program. To borrow a term from statistics, self-instructional programs may be called robust. In many cases the theoretical assumptions underlying the development of programs may not prove too important.
-7-

References


Ashbaugh, W. H. Effect on achievement of written responses to programed learning material for students of differing academic ability. Psychological Reports, 1964, 14, 780-782.


Moore, J. W., & Smith, W. J. Role of knowledge and knowledge of results in programmed instruction. Psychological Reports, 1964, 14, 407-423.


Footnotes

1 This research was supported by a grant from the Carnegie Corporation of New York to Educational Testing Service. The authors wish to thank Drs. Herbert Gerjuoy and Felix Kopstein for their helpful comments in reviewing an earlier version of the paper.

2 As part of a larger study, the small-step version of the program was also used in combination with a trained Spanish teacher. For 15 classes taught by the combination of teacher plus program, the Attitude toward Programed Instruction score correlated -.44 with Aptitude and -.53 with Achievement. Since there is no obvious substantive explanation of why the correlations should vary so, the best explanation may be that the correlations arose by chance.
### Table 1
Analysis of Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Source of Variation</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Achievement</td>
<td>Program Versions</td>
<td>1</td>
<td>25.6</td>
<td>1.4</td>
</tr>
<tr>
<td>(Predictor: Aptitude)</td>
<td>Error</td>
<td>36</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td>B. Interest in Spanish</td>
<td>Program Versions</td>
<td>1</td>
<td>.005</td>
<td>.004</td>
</tr>
<tr>
<td>(Predictor: Preattitudes)</td>
<td>Error</td>
<td>36</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>C. Attitudes toward Programmed Instruction</td>
<td>Program Versions</td>
<td>1</td>
<td>.025</td>
<td>.4</td>
</tr>
<tr>
<td>(Predictor: none)</td>
<td>Error</td>
<td>37</td>
<td>.063</td>
<td></td>
</tr>
</tbody>
</table>

*Adjusted Mean Squares shown for the outcomes of Achievement and Interest in Spanish.*
Table 2
Results for Two Versions of a Self-Instructional Program

A. Small-step Version (N = 17 Classes)

<table>
<thead>
<tr>
<th>Input</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aptitude</td>
<td>-01</td>
<td>70</td>
<td>04</td>
<td>75</td>
<td></td>
<td>106.5</td>
<td>6.6</td>
</tr>
<tr>
<td>2. Preattitude</td>
<td>-01</td>
<td>07</td>
<td>50</td>
<td>-08</td>
<td></td>
<td>4.8</td>
<td>.54</td>
</tr>
<tr>
<td>3. Achievement</td>
<td>70</td>
<td>07</td>
<td>-06</td>
<td>74</td>
<td></td>
<td>20.5</td>
<td>4.7</td>
</tr>
<tr>
<td>4. Interest in Spanish</td>
<td>04</td>
<td>50</td>
<td>-06</td>
<td>74</td>
<td></td>
<td>10.5</td>
<td>1.1</td>
</tr>
<tr>
<td>5. Programed Instruction</td>
<td>75</td>
<td>-08</td>
<td>74</td>
<td>-11</td>
<td></td>
<td>21</td>
<td>.21</td>
</tr>
</tbody>
</table>

B. Scrambled Version (N = 22 Classes)

<table>
<thead>
<tr>
<th>Input</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aptitude</td>
<td>-02</td>
<td>82</td>
<td>-19</td>
<td>-32</td>
<td></td>
<td>103.5</td>
<td>8.3</td>
</tr>
<tr>
<td>2. Preattitude</td>
<td>-02</td>
<td>21</td>
<td>71</td>
<td>-03</td>
<td></td>
<td>4.7</td>
<td>.66</td>
</tr>
<tr>
<td>3. Achievement</td>
<td>82</td>
<td>21</td>
<td>16</td>
<td>-27</td>
<td></td>
<td>20.2</td>
<td>7.8</td>
</tr>
<tr>
<td>4. Interest in Spanish</td>
<td>-19</td>
<td>71</td>
<td>16</td>
<td>-01</td>
<td></td>
<td>10.3</td>
<td>1.6</td>
</tr>
<tr>
<td>5. Programed Instruction</td>
<td>-32</td>
<td>-03</td>
<td>-27</td>
<td>-01</td>
<td></td>
<td>.52</td>
<td>.27</td>
</tr>
</tbody>
</table>

Note: Decimal points have been omitted from the correlations.
The following four questions deal with your opinions about taking Spanish. Please check one answer for each question -- whichever best describes how you feel. Remember, your answer will not have any bearing on your marks or your standing in the class, so please answer honestly.

16. How long would you like to study Spanish?
   - [ ] I would like to drop Spanish right now
   - [ ] Just this year, but no more
   - [ ] More than just this year

17. Do you think Spanish should be taught in the sixth grade?
   - [ ] No
   - [ ] Yes
   - [ ] I'm not sure

18. How much did you enjoy Spanish last year?
   - [ ] About the same as my other subjects
   - [ ] More than my other subjects
   - [ ] Less than my other subjects
   - [ ] I did not study Spanish last year

19. Did studying Spanish help you in English?
   - [ ] No
   - [ ] Yes
   - [ ] I'm not sure
STUDENT QUESTIONNAIRE

Last year in the fifth grade you learned how to speak Spanish. Now as sixth graders you are learning how to read and write Spanish. Some of you are learning to read and write Spanish from your teacher, others are learning from Automated Spanish, a programmed textbook, and still others from your teacher and programmed textbooks.

Here are some questions about Spanish and about the way you are learning it.

Read each question and the possible answers.
Decide on your answer.
Put a check mark like this / next to the answer you choose.
Make sure you answer each question.

1. How are you now learning to read and write Spanish?
   a. From my teacher
   b. From programmed textbooks
   c. From my teacher and programmed textbooks.

2. If you had your choice, how would you want to learn Spanish reading and writing?
   a. From my teacher
   b. From programmed textbooks
   c. From my teacher and programmed textbooks.

3. If you had your choice, how would you want to learn arithmetic?
   a. From my teacher
   b. From programmed textbooks
   c. From my teacher and programmed textbooks

4. If you had your choice, how would you want to study English?
   a. From my teacher
   b. From programmed textbooks
   c. From my teacher and programmed textbooks
5. If you had your choice, what foreign language would you like to learn in
the sixth grade?
   ____ a. French
   ____ b. German
   ____ c. Latin
   ____ d. Spanish
   ____ e. Russian
   ____ f. No foreign language

6. If you had your choice, what foreign language would you like to learn in
high school?
   ____ a. French
   ____ b. German
   ____ c. Latin
   ____ d. Spanish
   ____ e. Russian
   ____ f. No foreign language

7. How much did you enjoy learning to speak Spanish last year?
   ____ a. More than my other subjects
   ____ b. About the same as my other subjects
   ____ c. Less than my other subjects

8. How much do you enjoy learning to read and write Spanish this year?
   ____ a. More than my other subjects
   ____ b. About the same as my other subjects
   ____ c. Less than my other subjects

9. How often do you read Spanish newspapers, stories, and so forth on your own?
   Do not include your reading for class assignments.
   ____ a. Rarely or never
   ____ b. Once in a while
   ____ c. Often

10. How often do you translate Spanish on your own?
    ____ a. Rarely or never
    ____ b. Once in a while
    ____ c. Often
11. How often do you think in Spanish when you are not working on your class assignments?
   ___ a. Rarely or never
   ___ b. Once in a while
   ___ c. Often

12. How often do you speak to your friends in Spanish?
   ___ a. Rarely or never
   ___ b. Once in a while
   ___ c. Often

13. How often do you speak to your parents in Spanish?
   ___ a. Rarely or never
   ___ b. Once in a while
   ___ c. Often

14. How often would you like to take Spanish this year?
   ___ a. Every day
   ___ b. 4 times a week
   ___ c. 3 times a week
   ___ d. Twice a week
   ___ e. Once a week
   ___ f. Not at all

15. How long would you like to study Spanish?
   ___ a. I would like to drop Spanish right now
   ___ b. Just this year, but no more
   ___ c. More than just this year

16. Do you think studying Spanish helps you with English?
   ___ a. No
   ___ b. Yes
   ___ c. I'm not sure

17. Do you think studying Spanish helps you figure out the meaning of new English words?
   ___ a. No
   ___ b. Yes
   ___ c. I'm not sure