ON VALIDATING LEARNING HIERARCHIES

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SUMMARY

Using Gagne's task analysis a learning hierarchy for whole number addition was constructed. Based on the logical ordering of the subtasks, a test was constructed to assess mastery at each level. A second test was constructed using a randomization of the same items. Both tests were administered to 111 elementary school children in grades 3 through 6. Analysis of transfer between adjacent items using the P statistic (proportion of positive transfer) validated both the hypothesized sequencing and the randomly ordered subordinate levels. Results indicate this procedure is not a sufficient criterion for ordering the subordinate levels of a learning hierarchy using test data.

INTRODUCTION

Gagne (1968) suggested two approaches which can be used to evaluate learning hierarchies. In effect, both employ the study of positive transfer between two adjacent levels of a hierarchy at a time. A number of studies employing two-level analysis in conjunction with programmed learning sequences have been reported (Gagne and Brown, 1961; Gagne and Paradise, 1961; Gagne, Mayor, Garstens and Paradise, 1962; Gagne, 1963; Gagne and Bassler 1963).

There are four possible relationships in a two-level design:

A. Positive transfer from lower learning level to adjacent higher learning level, that is, lower level passed and adjacent higher level passed. (++)
B. Lower level failed and adjacent higher level failed. (--)
C. Lower level failed but adjacent higher level passed. (+-)
D. Lower level passed but adjacent higher level failed. (-+)

Proportion of positive transfer P between two adjacent subordinate levels of the hierarchy is calculated by the following formula:

$$P = \frac{A + B}{A + B + C}$$

If the proportion of positive transfer between adjacent levels is high ($P = .90$) the hypothesized ordering is considered verified.

The purpose of this study was to provide evidence that the procedure based on positive transfer between adjacent levels as described above is not an adequate model for verifying the hypothesized ordering of levels in a learning hierarchy from test data.

METHOD

Using Gagne and Paradise's (1961) procedure, a learning hierarchy for the computational skills of whole number addition was constructed. Based on the hypothesized ordering of the subordinate levels, a test (Form A) was constructed to assess mastery at each level. The test consisted of composite test items for each level in the hierarchy. Each composite item consisted of three items testing the same subordinate task. A sample test item for one level — two 2-digit addends with a sum less than 100 which require renaming 10 ones as 1 ten — is given below.

$$\begin{array}{r} 14 \\ +\ \underline{18} \end{array} \qquad\qquad \begin{array}{r} 35 \\ +\ \underline{25} \end{array} \qquad\qquad \begin{array}{r} 29 \\ +\ \underline{13} \end{array}$$

The entire test consisted of 33 composite items making a total of 99 items.

The above procedure of test construction is similar to the "H-technique" (Stouffer, Borgatta, Hays, and Henry, 1952). At each level pass (+) was defined as correct responses to at least two of the three items for that level.

A second test (Form B) was constructed using the same items as in Form A. However, items were not sequenced according to the hypothesized ordering of the subordinate levels of the hierarchy. The original 33 items were divided into two groups. Group I consisted of those items testing the subordinate tasks in the lower half of the hierarchy and Group II consisted of those items testing the subordinate tasks in the upper half of the hierarchy. The first 16 items on Form B were drawn at random from Group I. The remaining 17 items were drawn at random from Group II. This stratification prevented a subject at lower ability levels from being confronted with a task at the upper levels of the hierarchy at the beginning of the test.

Forms A and B were administered to elementary school children in grades 3 through 6 in order to obtain a wide range of ability levels. Two intact groups at each grade were tested. Test forms were randomly assigned to each group. Forms A and B were completed by 111 _S_'s each. Every _S_ tested was instructed to attempt each item.

The patterns of responses for each transfer in the hierarchy were analyzed. That is, a contingency table of the observed responses to a higher level item and the adjacent lower level item was constructed. The proportion of positive transfer between adjacent items on Forms A and B were compared in order to draw inferences about the validity of the hypothesized ordering of the levels (Form A) and the randomly ordered levels (Form B).

RESULTS

With Form A the proportions of positive transfer between adjacent levels as computed by Gagne's formula were all at least .90 except in one case (.84). Even this proportion is far above the purely chance values of these patterns which Gagne suggested would range between .25 and .50. Thus, the postulated ordering of the subordinate levels of the hierarchy was verified using this procedure.

With the data from Form B, the randomly ordered test, there were three instances in which the proportion of positive transfer between adjacent levels was below .90. One of these was .89, another was .78. The proportion of positive transfer between the last two items was .84. Therefore, except for the location of two levels, Gagne's procedure also validated the hierarchial arrangement of the randomly ordered subordinate levels.

The mean proportion of transfer between two adjacent subordinate levels of the logically ordered hierarchy was .97. The mean proportion of transfer between two adjacent subordinate levels in the randomly ordered hierarchy was .96. At the .01 level, there was no significant difference between the mean proportion of transfer between adjacent levels of Forms A and B.

The KR-20 coefficients for Forms A and B were .93 and .91 respectively. The coefficient of reproducibility (Torgerson, 1958) for Form A was .94; for Form B it was .91.

DISCUSSION

The results indicate Gagne's procedure is not a sufficient criterion for ordering the subordinate levels of a learning hierarchy from test data. Analysis of the pass-fail patterns by this procedure validated the hypothesized ordering of the hierarchy for the computational skills of whole number addition. However, a stratified random ordering of these subordinate levels was also validated by the procedure. Admittedly, there are numerous sequences of subordinate tasks which will facilitate positive transfer between the adjacent levels. However, the probability of a random ordering of such subordinate tasks yielding an optimal sequence is very low.

These results should be tempered somewhat by the fact that a complete randomization of the subordinate levels of the hierarchy was not used. Replications with complete randomization of subordinate levels and larger samples would be desirable. This study points out clearly that item response patterns are confounded by prior educational experiences. If a subject is exposed to instruction based on a specific sequencing of subtasks, his response patterns will reflect this. If a subject has the ability and achievement level to pass all 33 levels of the addition hierarchy, then regardless of the ordering of these subtasks he will pass all the levels. This is not to say that a sequence of subtasks cannot be arranged in a hierarchial ordering of complexity where each lower subordinate level is a necessary prerequisite to the others. It does indicate that data ordinarily analyzed in this manner — even in conjunction with programmed learning sequences — may be heavily laced with artifact. In particular, each datum eminating from a pair of levels both of which are already mastered by S and each datum eminating from a pair of levels both of which are totally unlearned by S, seem inappropriate to use. Indeed, to use these data tends to grossly inflate the proportion of positive transfer between two adjacent subordinate levels of any learning hierarchy. In short, an adequate procedure for analyzing learning hierarchies using test data remains to be developed.

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