An Analysis of Algorithmic Processes and Instructional Design

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The literature on algorithmic teaching and learning has had relatively insignificant influence on the technology of instructional design. A possible explanation is the fact that the subject has rarely been treated from a designer's point of view. In this article, a number of useful terms/concepts are offered to facilitate the process of understanding and creating algorithms. A procedure is suggested for applying these concepts in the context of an information processing model. Empirical evidence of the concepts' utility is offered. The ensuing design prescriptions are shown to be both theoretically and empirically valid, yet easy to recognize and use.

Algorithmic learning and instruction have undergone a number of comprehensive analyses (Gerlach, Reiser, & Brecke, 1975; Landa, 1974, 1976, 1983). Although such analyses do make instructional designers aware of the effectiveness of algorithms, the rigorous procedures demanded are seldom applied in the real world. Designers and developers remain unconvinced of the approach's expedience. Consequently, the main purpose of this article is to show how algorithms can be readily applied to the design of instructional systems.

We hope to achieve this goal by progressing through three stages. First, a number of simple, useful terms are offered that describe an algorithm. Second, these terms and their inherent functional characteristics are related to a standard information processing model. This exercise demonstrates theoretically and logically the validity and power of algorithms to improve the instructional outcome. A number of concrete prescriptions are offered for the development of algorithms. Third, the results of several studies are examined to empirically assess the value of the design prescriptions. The conclusions provide several additional guidelines for implementing algorithm-based instruction and suggest where instructional research and design might be going.
DESCRIPTIVE TERMS

The algorithm-based design approach can be used in one or more of the following general ways: (a) in conjunction with front-end analyses to identify and organize content and procedures, (b) as a means of generating guidelines for the activities of the instructor, and (c) to generate guidelines or precise directives for the student.

Every algorithm can be represented in at least one form, e.g., flowchart, decision table, prose, etc. The representation generated by the approach provides both the content of the task (be it cognitive, affective, and/or psychomotor) and the sequence by which the steps are executed. The objective of most instruction is to teach people how to do something, and any given algorithm represents one way of doing it.

The easiest way to visualize an algorithm is by means of a decision tree or flowchart. Each step, or unit, represents a discrimination (decision or answer) or operation (task) which leads to the next step. Figure 1 represents a fairly common type of algorithm.

The five terms to be analyzed in this article are applied to the algorithmic representation in Figure 1; they are best understood when applied to decision tables or flowcharts, though the principles apply to any representational form. The first two terms refer to the physical characteristics of the algorithm, while the second three refer to processing characteristics. (See Schmid, Gerlach, and Valach [1978] for a more detailed treatment of these terms.)

The first two terms, depth and width, are fairly self-evident. The depth is the number of levels represented. A level is formed at each new serial step in a branch, so the depth is determined by the longest branch. In Figure 1, there are five levels in Branch A → B → E → F → I and the levels are labeled I.

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**FIGURE 1**

Algorithm for Test Selection of One-Factor Designs. (Content for illustration purposes only.)

**Domain:** A design description providing the type of data, between or within group relation, source of data (sample or population), and n size.

**Range:** Statistical test to use.

**Entry Skills:** Knowledge required to discriminate among domain content choices.

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A

**TYPE OF DATA**

Are the data interval/ratio level?

YES   NO

B

**BETWEEN OR WITHIN SUBJECT FACTORS**

Are the same subjects used in each group?

YES   NO

C

**TYPE OF DATA**

Are the data ordinal?

YES   NO

D

**POPULATION VARIANCE**

Are the population scores, means or standard deviations known?

YES   NO

E

**POPULATION VARIANCE**

Are the population scores, means or standard deviations known?

YES   NO

F

**TOTAL SAMPLE SIZE**

Does the sample equal or exceed thirty?

YES   NO

G

**USE A Z-TEST FOR DEPENDENT MEANS**

H

**USE A Z-TEST FOR DEPENDENT MEANS**

I

**USE A Z-TEST FOR INDEPENDENT MEANS**

J

**USE A Z-TEST FOR INDEPENDENT MEANS**

K

**USE A SIGN TEST**

L

**USE A CHI-SQUARE**