DOCUMENT RESUME

ED 126 854 IR 003 758

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TITLE Learning Systems Research, Development, Testing and Evaluation.
PUB DATE 21 Jul 76
NOTE 13p.; Paper presented at the International Learning Technology Congress and Exposition on Applied Learning Technology for Human Resource Development (Washington, D.C., July 21-23, 1976)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Achievement; Comparative Analysis; Complexity Level; Cost Effectiveness; Educational Strategies; Higher Education; *Instructional Design; Instructional Technology; Learning; Models; Research Needs; *Systems Approach

ABSTRACT

A project to determine the level of development complexity necessary to produce cost-effective instruction is described. The project is designed to investigate alternative levels of instructional development complexity, how these different levels affect spending, varying degrees of student achievement associated with each level, and the time required to develop the materials. The three levels of instructional development complexity considered are: (1) A formal approach in which systematic procedures are strictly and formally applied; (2) a semiformal approach in which only selected steps are strictly applied; and (3) an informal approach in which none of the steps typically employed in systematic development are used. (Author/HAB)

LEARNING SYSTEMS RESEARCH, DEVELOPMENT, TESTING AND EVALUATION

by:

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Paper to be presented at Second Symposium on Applied Learning Systems: Professional Development Program, July 21, 1976.

The Problem

The application of basic scientific-technological methodology to learning systems is not a recent phenomenon. Having its genesis in the programmed instruction movement, what we now call instructional technology, instructional system development, or the systems approach has been applied to a vast number of military, industrial, and educational training development efforts (Saettler, 1968). The behaviorally-oriented systems approach to instruction prescribes the following interdependent operations as a means of achieving learning effectiveness: (1) Selecting responses to be practiced on the basis of behavioral analysis of learning tasks; (2) deriving objectives from the behavioral analysis which describe the behavior at the end of training; (3) developing test items which sample the behavioral domain specified in the objectives; (4) selecting media which have instructionally relevant stimulus display and student response capabilities; (5) field testing the material on a representative sample of the target population; and (6) revising the material on the basis of the tryout results so that training objectives will be achieved.

Research on components of the systems approach and system development state-of-the-art, theory and practice have been reported elsewhere (Baker, 1973), but a review of the literature failed to uncover research on the relative effectiveness of systematic development per se.

A number of formal, rationally derived procedural models have been developed which operationalize the above steps and thus guide the development of instructional material (Briggs, 1970; Butler, 1967; Drumheller, 1971; Gropper, 1971; Schumacher & Glasgow, 1974; Smith, 1966; Wong & Raulerson, 1974). Typically, the models specify step-by-step procedures,

which if followed will presumably lead to instructional materials which result in instructional materials of a higher quality than those developed using a less systematic or an unsystematic approach. While developmental costs are higher than when less formal approaches are used, the argument usually put forth in its defense is that it is more cost effective since more students achieve a higher standard of performance. Yet, the sheer complexity of some of the developmental models cast doubt on this assumption. For example, the Northwest Regional Educational Laboratory includes 37 steps in product development and installation, 31 of which are directly related to development (Baker, 1973). The American Institutes for Research (Gropper, 1971) has published a model which contains 37 macro steps, with a greater number of micro steps subsumed under these. Therefore, one must logically ask if the scope of the developmental undertaking is worth the payoff.

Anyone who has attempted systematic development knows that, if done properly, it is a time-consuming task, and because time means money, it can also be costly. However, in some fields where the demand for trained, qualified personnel exceeds supply, the instructional technologist is under tremendous pressures to produce high quality training within very constricted time frames, and often under budgets established by managers who have little understanding of the instructional development requirements. Therefore, given the kinds of pressures on instructional designers in applied learning, it is imperative that ways of reducing costs while maintaining professional standards be explored.

Research Needs

While it is the conventional wisdom that systematic development is cost effective, no empirical test of the validity of this assumption has been conducted. The cost effectiveness of using different teaching methods and programs has been evaluated within some elementary, secondary, university, and professional schools (Levin, 1975), but cost effectiveness of developing self-instructional materials through different instructional development approaches has not been compared. That is, for a given set of instructional materials, data do not exist which show comparison of test scores, comparison of costs associated with the application of different approaches to producing the instructional material, and comparison of times required to develop the instructional material. While there seems to be a surfeit of guides for employing the systems approach to develop instructional programs, the research in support of such practice in development is yet to be found.

Variables likely to influence cost effectiveness include:

1. The degree to which all steps in systematic approaches are formally applied. (The manner in which developmental steps are executed.)
2. The complexity of the learning tasks which are the object of instruction.
3. The orientation of the organization and personnel responsible for developing instruction.

The Execution of Steps in Procedural Models

Strict, formal application of steps delineated by instructional design models may be more critical in the development process than others. Formal

analyses or procedures are important when they force the instructional technologist to come to grips with issues in more substantive ways than he might otherwise; structures the technologist's behavior so that all relevant factors are more likely to be considered than overlooked; and provides a tool which reduces unproductive behavior, and thus allows the instructional technologist to more quickly arrive at an effective solution. However, for certain steps the same results may be achieved from less rigid, heuristic approaches which do not rely on the kind of highly proceduralized, formal analysis specified in many developmental models. Therefore, there exists a need to determine the level of development complexity necessary to produce cost-effective instruction.

Applied Science Associates is participating in a study being conducted by the National Library of Medicine (Note 1). In the study, ASA will develop a set of instructional materials using a semi-formal approach. The project is designed to investigate alternative levels of instructional development complexity, how these different levels affect spending, varying degrees of student achievement associated with each level, and the time required to develop the materials. The three levels of instructional development complexity are: (1) A formal approach in which systematic procedures are strictly and formally applied; (2) a semi-formal approach in which only selected steps are strictly applied; and (3) an informal approach in which none of the steps typically employed in systematic development are used.

In using the semi-formal approach, we will conduct the following in a structured fashion: analyze learning tasks, formulate objectives, and revise the material. We believe the formal approach is critical in conducting

Note 1: The research upon which this publication is based is being performed pursuant to Contract No. N01-LM-6-4731 with the National Library of Medicine, National Institutes of Health, Department of Health, Education and Welfare.

a learning analysis because the conditions to be established for effective learning depend to an important extent on the identification of what class of human performance is to be learned (Gagné, 1965). Precisely stated objectives derived from the learning analysis are important because they aid the instructional designer in planning his instructional package and to later evaluate its effectiveness.

Finally, formal revision strategies are critical when they focus on types of errors, rather than error rate, and systematically take into account the probable reasons for failure of strategies prescribed earlier, and address themselves to why the treatments so obviously failed. If revision proceeds on an ad hoc basis instead, then the tryout and revision cycle is likely to be extended until the instructional designer "hits" on the right strategy, thus extending developmental time and costs.

How we intend to avoid formal analysis in some steps, while performing it in others probably needs clarification. In the systems approach to instructional development, the output of each step serves as the input to the next step. For example, the foundations for test construction are set when behavioral objectives are written. However, test development may follow one of two divergent paths: informal and formal. In the informal approach, test development begins when the test writer attempts to produce items which incorporate the response condition specified in the objective. Thus, an objective which calls for the student to select a response should, at best, have with it items where the learner is actually making a choice. The stimulus ends of items are based on the writer's subjective decisions about stimulus boundaries and variability. He builds a test which he judges to be of reasonable length to allow generalization about the specific types of tasks an individual can perform. For some types of performances,

the relevant domain of test items can number into the thousands, but decisions about test length are usually tempered by practical considerations rather than strict consideration of variables such as task variability. Thus, he follows no formalized procedures, but rather develops items which, in his best judgment are appropriate for the objective as written. In sum, while based on systematically derived objectives, most decisions regarding content limits, distractor domains, formats, length, etc. are, in fact, arbitrary (i.e., informal).

In contrast to the above approach, a theory of domain-referenced test construction has evolved which specifies highly formal, systematic procedures for constructing tests. Baker (1974), for example, identifies six steps of domain-referenced test specifications including rules of content eligible for test inclusion, rules for inclusion of wrong-answer alternatives in multiple choice items, and rules in sampling the item pools. We propose to avoid the type of highly proceduralized, systematic analysis in which a large number of test items are generated according to given rules, and then randomly sampled to constitute the test. Rather, we will follow the informal, unstructured approach described in the above paragraph.

Also, it is not our intention to conduct a formal field test in which a randomly selected sample of the target population is tested on the program in an operational setting. Nor do we intend to systematically repeat a tryout and revision cycle until a predetermined criterion is reached. Many instructional development models have carefully prescribed procedures for field testing materials. The Briggs' model (1970), for example, recommends eight separate activities for formative evaluation alone. We intend to avoid any approximation of any standardized or formalized procedures.

Yet, inherent in our decision to formally implement the revision step, is the need to collect tryout data. We intend to collect this data by having students try out the materials as they are developed. Tryouts will be conducted whenever the project staff judge the materials to be in a reasonable form, and no consideration will be given to how well subjects represent the population. How many students will take part in the tryout, whether all students will encounter the material collectively or not, and whether all students will encounter the same version of the material will be determined by practical considerations, rather than formal requirements.

The steps in a systems approach are interdependent, and this fact has important implications for the study. For example, it can be argued that the formulation of objectives is inherent to the development of an objective test. Whether the objectives are formally constructed and systematically written down or simply a set of ideas in the mind of the test developer, they are, nevertheless, established. In the first case, they are formalized according to some set of rules before the test development phase; in the second case, they evolve heuristically as the test is being developed. Therefore, the difference between an informal and formal approach is <u>not</u> whether objectives were developed, rather the difference is whether they were formalized. This line of reasoning can be extended to the tryout and revision steps. We cannot logically revise material which has not been tried out. But we can avoid any formalized procedures, and simply and informally, gather information while strictly and rigorously analyzing the data.

This initial effort will make an important contribution toward a better understanding of the practical role played by formal developmental models. There are, of course, other factors which may influence cost-effectiveness.

The Difficulty of the Learning Task

While a learning analysis is a critical step in the development process, its relative effectiveness may differ depending on the nature of the learning task. If a learning task is judged to be easy, for example, it may be cost effective to allow the instructional technologist to set up objectives (omitting a formal analysis) and proceed with designing instructional strategies. It has been our experience that often during the process of developing lesson plans, the programmed text, or other instructional material, the designer heuristically uncovers critical task variables that influence learning outcomes and designs instruction accordingly.

The implication of this is that the task analysis activities are, in fact, taking place, but simultaneously with development rather than preceding it. The difference is that with this approach, criterion objectives may be achieved without having performed the task analysis in any formal way, and much unnecessary work documenting task analysis results will have been avoided.

When the criterion objectives are not achieved, the kind of error analysis previously discussed will identify those elements of the learning task requiring systematic analysis. If revision strategies are the mirror image of learning analysis, the previously omitted learning analysis will be performed post hoc. But now, it will focus only on those aspects of the task where learning has so obviously failed. Thus, if a substantial part of the instruction remains intact, analysis will be less than full scale. Consequently, less time and money will have been expended.

In sum, task difficulty is a variable which should be evaluated in addition to levels of developmental complexity when exploring ways to reduce cost while maintaining professional standards. It may be that for

less complex tasks, front-end analytic developmental activities can be precluded, but the same activities may be imperative for more complex forms of learning because of the probability that without it, instruction will seriously miss the mark and substantive, costly revision ensue.

Orientation of Organization and Personnel

One of the dangers in the delineation and dissemination of stages of critical events or steps in development is that they may be formally employed, but incompletely understood. For example, in an assessment of needs, (Schumacher, et al, 1972) personnel responsible for designing instructional systems and developing training courses reported considerable difficulty with all of the major elements of the process although they had been using it for some time. Those activities identified as the most troublesome included the two areas of greatest technological advancement: task analyses and behavioral objectives. Neither practice is new. With respect to objectives, virtually all educational and training personnel who plan, develop, approve, administer, or manage instruction and its supporting material are aware of the criticality of precisely stated objectives. Yet, despite all the guidance which has been published, people apparently are still failing to understand and apply the process in any meaningful way.

NIE's Group on School Capacity for Problem Solving reports that many educational innovations fail because they are implemented poorly or not at all (Tucker, 1975). NIE reports that with respect to Federal programs, neither the way in which they were framed and managed, nor the size of the funding accounted for most of the variance in implementation success. What really counted was the orientation of those receiving the funding, and certain organizational and managerial characteristics of the project and institution. It is no wonder that so many innovations produce "no significant differences."

Results from research on systematic development are likely to show the same results unless funding sources develop mechanisms for avoiding the all too common situation in which a practitioner's ability to use the jargon of the field is misconstrued as evidence of his ability to meaningfully implement a systems approach. Developers participating in research must have a good understanding of systems analyses methodologies and procedures as problem solving tools, rather than a series of steps which, if mechanically followed, will produce cost-effective outcomes.

Therefore, if organizational factors are important determinants of the success of innovations, and the quality of educational outcomes, then we must begin now to identify those organizations where innovations have been successful, and describe the methods and capacities of their organizations in order to develop and train future professionals in their image.

Summary

Clearly, there has been no lack of literature describing instructional system practices and procedures. However, pressures exerted by the nation's political, professional, research, and economic subgroups to train more qualified personnel faster in fields such as the health professions, have created a need to examine ways of reducing costs while maintaing professional standards and creating a more efficient instructional process. Three of the many factors that must be explored in order to intelligently assess alternative strategies were discussed.

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