Evaluation Technology in Instructional Development

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Instructional development involves the systematic application of instructional and learning principles and theories to the planning and implementation of learning environments. Wherever possible, it uses interdisciplinary research and theory to aid in the understanding of variables that contribute to the development of effective instruction. Information from related fields of inquiry has helped to specify optimum conditions for learning as well as provide efficient ways for planning the learning that is to take place. Psychology, computer science, management information sciences, and educational technology have contributed to the definition of a set of prescriptive variables which can be applied systematically to the development of instructional materials (Glaser and Resnick, 1972).

The systematic application of these prescriptive variables can be expressed as a model for planning and implementing instruction. Since Glaser's (1965, 1966) original model for instructional development, a number of others have appeared (for example, Briggs, 1970; Gerlach and Ely, 1971; Kemp, 1971; Merrill, 1971; Popham and Baker, 1970). Most of the activities represented in these models—behavioral objectives, pretest, instructional activities, posttest and revision—are familiar to educators. Most of the newer instructional models (for example, Dick and Carey, 1977), even with their increased complexity and decision strategies, offer the same general characteristics.

With this in mind I am presenting another model of instructional development but rather than characterizing it by the usual boxes and arrows of a flowchart, this model identifies the principles and theories associated with the process of instructional development. The assumption made here is that with each application of these principles and theories, a unique sequencing (perhaps as a flowchart, but not necessarily) of the development activities will be produced. Another difference between this model (Figure 1) and earlier models is that evaluation is included in every phase of development (Tennyson, 1976). As noted above, evaluation has been relegated to the last step in the process—this has usually occurred because of the limitations of flowchart techniques to describe the complexity of both development and evaluation.

The model used to identify the generic prescriptive variables has four phases: assessment, design, production, and implementation (see Figure 1). Within each of these phases are two main activities, development and evaluation. Additionally, the model includes reference to products associated with each phase. As a description of the model, development and evaluation activities will be reviewed and suggested for use. It is assumed, however, that each developer will define his or her own specific strategy of development based upon an analysis of their particular situation. This is a descriptive model to aid in instructional development; it is not intended to be restrictive.

Assessment Phase

Instructional development usually begins with an assessment of the learning environment to determine if an instructional need or problem exists (Merrill and Wood, 1975). The environment is assessed to provide data to answer the question: Would an instructional development effort be feasible and desirable? This activity defines the conditions and parameters of the problem from which specifications for the instructional development project can be proposed. The procedures and findings of the assessment phase are evaluated to determine whether to adopt currently available instructional materials, modify existing instruction, or develop new instructional materials. If either the second or third option is selected, the instructional development would continue through the remaining phases (Figure 1). However, selection of the first option—to adopt—would require only the implementation phase.

The assessment phase involves two concurrent processes: (1) specification of the instructional problem, learner characteristics, situational variables, and instructional objectives, and (2) evaluation of the assessment process and its results to determine the feasibility of adopting, modifying, or developing instructional materials.

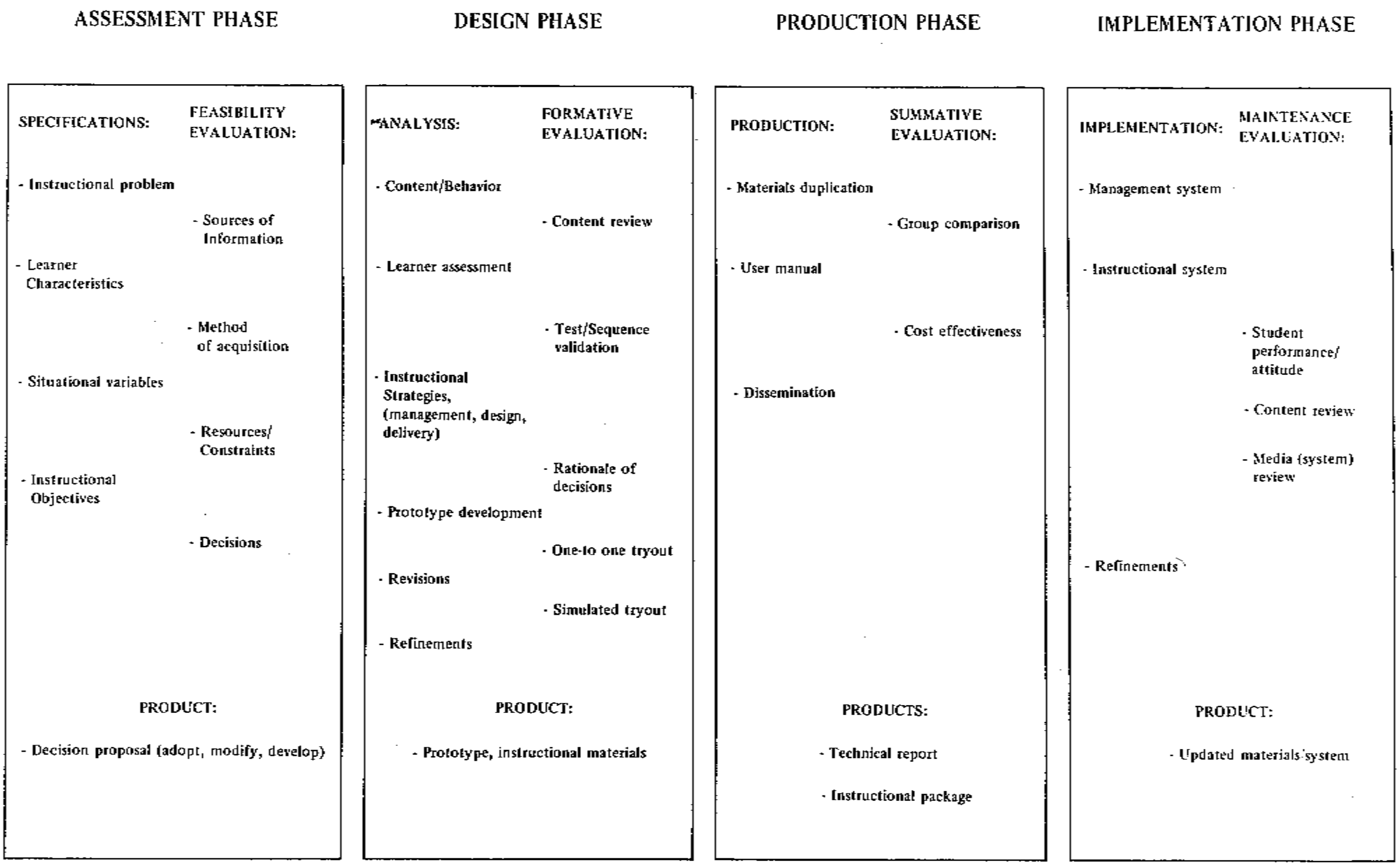

Figure 1. Phases of instructional development.

Specifications and Feasibility Evaluation

An instructional problem is usually assessed and defined in terms of curriculum needs and goals (Taba, 1962). This relationship of instructional development to curriculum development, however, is a fairly recent phenomenon (C. Tennyson and R. Tennyson, in press). The concern for instructional and curriculum problem identification is directly related to federal support for schools. Since the implementation of Title I, the Elementary and Secondary School Act of 1965, educators have had to develop detailed goals and objectives that were "behavioral, measurable, and representative of cognitive, affective, and psychomotor domains"[1] to obtain federal funds. The original curriculum needs assessment procedures initiated a new emphasis in educational evaluation to accurately determine the goals and objectives of education. Space does not permit a complete review of the curriculum evaluation methods, but they have been well defined (Grobman, 1968; Phi Delta Kappa National Study Committee on Education, 1971; Provus, 1971; Stake, 1967, 1969).

Instructional problem. Assessment methods used in the specification of the instructional problem are still for the most part qualitative, but the trend is toward obtaining data from quantitative sources, for example, surveys, job analyses, competency analyses, and curriculum goal analyses. Such data can be acquired and interpreted by analyzing school curriculum, governmental educational policies, other governmental regulations (for example, affirmative action), community needs, societal concerns, and educational research and theory. The instructional problem assessment process should provide information that specifies the needed content and behaviors to be learned within a given segment of the curriculum. The first step in the feasibility evaluation process (Figure 1), is the validation of sources used to define the instructional problem. Literature in this area appears to be endless with much of it focusing on various data sources. Just a few of the primary sources include, for example, society (McClure, 1971), students (U.S. Office of Education publications, U.S. Bureau of the Census, Institute for Social Research; Vol. II, Vol. III, Vol. IV), family (Mosteller and Moynihan, 1972), and career planning (Occupational Outlook Handbook, published biennially). The source, then, becomes the variable of evaluation.

Learner characteristics. Research has demonstrated that assessing the aptitudes and attitudes of the target population should be considered when instructional materials are being designed (Cronbach and Snow, 1977; R. Tennyson and Woolley, 1971; R. Tennyson and Boutwell, 1973). The assumption is that learning can be facilitated if the instruction can be adapted to the aptitude of the individual learner. Likewise, learner attitude seems to be an increasingly important factor in the development of learning environments (Gagné, 1972). Evaluation of learner aptitude and attitude follows from the method of acquisition—actual collection of data from the target population or from literature sources (for example, Guilford, 1966; Piaget and Inhelder, 1969).

Situational variables. Before instructional objectives can be established, the resource and facilities of the learning environment need to be assessed (Davies, 1973). These include not only the instructional resources of the learning environment but also the resource capabilities (facilities, funding, and staff) for doing the instructional development. Davies (1973) emphasizes the need to maximize the instructional resources; however, constraints inherent in those resources must also be recognized. The concept of constraints implies both the physical limitations and the capabilities of the resources for facilitating learning. Analysis of the situational variables should provide information on the characteristics of the learning environment—that is, the potential learning and instructional capabilities of the available resources and facilities and the requirements for modification and development activities.

Another concern is the availability and organization of knowledge (King and Brownell, 1966). The purpose for attending to subject matter here is to bridge the gap between the curriculum structure and the content (or task) analysis done in the design phase (Figure 1). At this stage of development it seems sufficient to establish what subject matter is desirable and appropriate for attaining the curriculum goals and to leave the detailed content organization to the design phase (Klahr, 1976). Evaluation of this component is actually done concurrently with the instructional objectives.

Instructional objectives. The data obtained from the specification procedures are used to specify the instructional objectives for the learning environment. Objectives at this point in the development process define the intended content and behavior the student will demonstrate as a result of instruction, not performance on a posttest system of assessment. Evaluation of instructional objectives seems to be a qualitative activity requiring a continuous review and adjustment (Kapfer and Ovard, 1971). That is, the intelligence, insight, values, attitudes, and beliefs of those associated with the learning environment judge the validity of the instructional objectives.

Product

It is at this point that the decision can be made as to how to proceed in solving the instructional problem. One form of documenting this solution is the preparation of a proposal which states the rationale for the instructional development decision and the specifications for accomplishing the stated objectives (R. Tennyson, 1977).

Feasibility evaluation focuses on documentating both the validation of the assessment procedures and the rationale of the specifications (Provus, 1971); that is, complete information should be provided on how the data were collected, from whom they were collected, and what method of validation was used. Documentation should also demonstrate how the objectives directly relate to the specifications derived from assessing the problem, the learners, and the situational variables (Saylor and Alexander, 1974). An additional form of evaluation involves an analysis of the likelihood that a developmental effort would result in a product that justifies the estimated time and resource expenditures (Temkin, 1974). Currently, most cost-estimation procedures used in instructional development are designed for either summative evaluation or for continued use of a product (Silvern, 1972; Temkin, 1974). Applying the principles of cost benefit analysis, which include direct costs and learning effectiveness and efficiency, to this front-end assessment makes it possible to establish more precisely the costs of the development effort.

Design Phase

The second phase of instructional de-

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[1] U.S. Office of Education. *State plan administrator's manual, ESEA, Title III.* Washington, D.C.: The Office, 1971, p. 20.

velopment deals directly with the design of the instructional materials. Design is that area of instructional development that has received the most research and theoretical development, yet it is probably the least-used phase in instructional development. This paradox occurs because of the division between the researcher and the developer. The failure to apply research findings to development, however, is probably due to poor communication rather than the unwillingness of developers to use research findings. Publication of several books and articles by researchers on applied design considerations gives testimony to the growing recognition of this problem. One can cite, for example, Gage and Berliner, *Educational Psychology* (1975); Gagné and Briggs, *Principles of Instructional Design* (1974); Klausmeier, Ghatala, and Frayer, *Conceptual Learning and Development* (1974); Merrill and Tennyson, *Concept Teaching: An Instructional Design Guide* (1977); and Snelbecker, *Learning Theory, Instructional Theory and Psychoeducational Design* (1974). Furthermore, a review of authors in *Educational Technology* and *Journal of Instructional Development*, would demonstrate that researchers are producing materials that explain design procedures in nontechnical terms.

Analysis and Formative Evaluation

The analysis component of the instructional design phase bridges the gap between the general guideline specifications of the assessment phase and the actual development of the instructional materials (Figure 1). The tasks associated with this activity include analysis of the content and behaviors defined in the instructional objectives, construction of the learner evaluation materials, selection of management, design, and delivery strategies, and development of an instructional prototype.

In general, the purpose of formative evaluation is to obtain data necessary for making revisions and refinements of the instructional materials during the design phase (Figure 1). Refinement refers to adjustments within single elements of the instructional design (that is, content/behavior analysis; performance objectives; tests; and strategies for management, design, and delivery) which do not affect the other elements; revisions, on the other hand, refer to alterations in one element which produce changes in one or more of the other elements. Data used for making revisions and refinements are derived concurrently with each element of the design phase processes. Formative evaluation includes such activities as review of the content/behavior analysis by subject matter experts (SMEs), validation of the test and instructional sequence, a one-to-one tryout of the prototype materials, and finally a tryout of the materials in a simulated learning environment.

Content/Behavior. The design of instruction ultimately centers on the subject matter to be learned and the behavior required of the students toward that content. Such an analysis consists of determining the most efficient arrangement of that knowledge for purposes of learning (Simon and Hays, 1976).

Formative evaluation of the design phase usually begins with a review and critique of the content structure by subject matter experts. The scope and sequence of the subject matter for instruction (content structure) is typically determined by a consensus of scholars in that discipline. If the analysis of content and behavior has resulted in the alteration of the conventional content structure, review by subject matter experts usually helps to ensure the integrity of that content. This review process can be particularly useful in making refinements of the content structure, because learners are usually too naive to offer criticism. The techniques for conducting a content review are presented in several curriculum development sources (for example, Saylor and Alexander, 1974).

Learner assessment. Design of a learner assessment procedure follows the analysis of content and behavior. Learner assessment involves the construction of an instrument to evaluate the learner's achievement of performance objectives (Anderson, 1972).

Criterion for acceptable performance on the assessment instrument should be established once the test and instructional materials have been validated. Rather than allocating an arbitrary standard for criterion performance such as the often-assigned level of 90 percent, performance criterions should be based on realistic expectations derived from the target population's interaction with the instructional and testing materials. Implied here are two forms of learning criteria. The first as defined in the instructional objectives (assessment phase), identifies the behaviors to be exhibited by the student when completed with the learning environment—including both instructional materials and tests. The second establishes a level or levels of acceptable performance on the with-learning environment assessment procedures.

The learner assessment instrument should be validated prior to the development of the prototype instructional materials for two basic reasons. First, the instrument should be designed to evaluate student learning of the defined content/behavior area, not just to provide an assessment of student learning of the specific instructional materials. Second, a validated test can be used for evaluating the structure (sequence) of the instructional content/behavior (R. Tennyson, 1972).

Instructional strategies (management, design, delivery). A concern in the design of the instructional materials is the design of the management system (Figure 1). The management strategy design will of course depend on the size of the instructional development project. If only one course is being developed it is possible to have only one form of management strategy, but if several courses or even an entire curriculum are being developed the management strategy can include many options. The options available for the management system depend on the specifications for both the learning environment and the instructional materials.

The second instructional strategy—design—refers to variables used for sequencing and presentation format of the instructional material. It is also with this area that we find the most extensive research efforts. Because the scope of this paper prevents a detailed or comprehensive review of this area, I will only direct the reader to the following reviews: Frase (1975); Klahr (1976); McKeachie (1974); Treffinger, Davis and Ripple (1977); and Wittrock and Lumsdaine (1977). The research findings seem to support Gagné's (1972) hypothesis of three basic cognitive behaviors: verbal information, intellectual skills, and cognitive strategy, each requiring a different design strategy for presentation of the instructional materials.

The delivery strategy should be selected with regard to the design strategy, the situational variables, and the management strategy. The variables and criteria in media selection models differ widely; most are technology oriented although a recent model by Merrill and Goodman (1972) recommends selection of media according to design, behavior, and resource capabilities. The flexibility in media selection models results from both the focus of the authors and the almost total lack of empirical data on whether students learn better from one form of media than another. An additional factor that should be considered in media selection is the concept of transmediation: a transfer from the original medium to another medium form. The transmediation capability is a factor to consider with individual learner variables.

Development of prototype. The procedures for the development of an instructional prototype have gone through a series of changes as the result of applied development work rather than of research findings. As the research on production variables advances, there will develop a more scientific approach to the actual development aspect of the instructional design process. Because empirical knowledge is lacking on this topic the evaluation procedures become important. Current understanding of the development process comes from clinical casework projects rather than true experimental situations, and as the development cases increase, certain variables and conditions will obtain a quasi scientific value. These casework projects have found, however, that an important element of efficient development is the formulation of a plan for administering the development process.

Additional elements to be considered in prototype development are message design (Fleming, 1970) and transmediation. These variables relate to the various ways in which a learner could perceive and interpret a message due to its presentation by a delivery system. Care must be taken to avoid misrepresentation. Once content is coded into a message on a delivery system, one-to-one and group tryouts can be instrumental in detecting any perceptual errors on behalf of the learner.

As in the other forms of evaluation, the purpose of a one-to-one tryout is quality control. Procedures for a one-to-one tryout are well established in the literature and involve the developer as the observer while the student attempts to work through the instructional materials (Bloom, Hastings, and Madaus, 1971; Cronbach, 1963; Eiss, 1972; Wittrock and Wiley, 1970).

The purpose of the simulated tryout is twofold. First, information is obtained for making refinements of the materials prior to full production. Variables to be considered include pretest/posttest scoring patterns, confidence ratings, and learner time spent on the instructional materials. Second, posttest scores from the simulated tryout can be used to establish a criterion for student performance. That is, the criterion for a test is founded upon normative data if it is to reflect a reasonable expectation for a given population of learners. Learning from instructional materials can be inferred if a significant gain in student performance occurs between the pretest and the posttest. More extensive data interpretation beyond observation of score differences will result from using multiple forms of data (for example, pretest/posttest scores, confidence ratings, and learning time).

Product

The design phase concludes with the completion of the instructional product. This phase, like the others, uses evaluation heavily to help validate the procedures and products, but it also differs because of the extensive research which moves development towards a scientific activity. The two concluding phases, production and implementation, follow the pattern of the initial assessment phase. That is, there is minimal scientific research to support the procedures defined, and the evaluation activities serve as a raw empiricist approach; the scientific foundation of the two remaining phases is based upon case study evidence.

Production Phase

The purpose of this third phase of instructional development is to produce the instructional prototype for use in the learning environment. Packaging the instructional materials usually implies that someone besides the original developer will be using the product. In most instructional development projects the assumption is that the product will be design dependent rather than teacher dependent. The design dependent concept increases the potential market of users. The need for packaging and disseminating instructional materials to reduce duplication of effort has resulted in the establishment of several clearinghouses for instructional products dissemination.

Documentation of instructional materials in a systematic procedure started with the guidelines for programed instruction issued by the National Education Association (1969). Those guidelines dealt with providing information on the rationale for decisions made in the design and included results of formative and summative evaluations. The original list still covers the main points for documentation of instructional development. Missing from those guidelines are the data and conclusion of the assessment phase, several components of the design phase, much of the information in a summative evaluation, and all of the implementation phase (Figure 1). Documentation standards now follow closely those established for research reporting and test construction.

Concurrent with the production of the instructional materials is the evaluation of those materials in the learning environment where they are to be used. The purpose of the summative evaluation is to document the degree to which the instructional materials meet the objectives of the instructional development effort. This evaluation centers on the degree that students learn the defined content and behaviors (R. Tennyson, 1977). Evaluation data for the documentation should include student performance reported in gain scores and compared with a control group, student learning time, learner attitudes, and costs. These data should be collected by presenting the instruction in the conventional learning environment; that is, as much as possible, the students should view the instructional materials as part of their normal learning experiences. The purpose here is to minimize the experimental effect that is present in the formative evaluation procedures.

Group comparison. Summative evaluation provides documentation that the developed instructional materials actually teach the content and behaviors defined in the instructional objectives. Gain scores (pretest/posttest) can be used here, but a more powerful method would be some type of multiple group comparison study in which the performance of students who receive the instruction is compared with the performance of students who receive some alternative instruction (R. Tennyson and Boutwell, 1971). There are variations of this control group design and many sources which illustrate them (for example, Merrill and Tennyson, 1977). This control group design can be useful in a summative evaluation if basic descriptive information on the control group is given in the documentation.

Determining the efficiency of the instruction is a second important purpose of summative evaluation. Only recently have developers actually attempted to collect this type of data, but most instructional development sources (for example, Gagné and Briggs, 1974; Davies, 1973) do not provide information on why or how to collect time data.

Efficient instruction can: decrease the amount of time required for learning; make time available for additional learning; save money where productivity is a goal; and usually improve motivation. Time data can be collected simultaneously with effectiveness data. Basic time data would indicate (1) time necessary for directions, (2) time required for the different instructional units, (3) time required for outside study, and (4) total time required for learning the objectives.

Learner attitude toward the instruction seems to be gaining as much emphasis in evaluating instruction as efficiency and effectiveness (Doyle and Whitely, 1974). The immediate problem is how to measure student attitudes in terms of conventional instructional methods. In the past, the most reliable form of student evaluation has been the single question, "How do you rate this instructor's overall teaching ability?" (Doyle and Whitley, 1974). This question is not comforting or suitable when attempting to evaluate an instructional product. Attitudinal responses should be specific to the definable characteristics of variables of the instruction. Composite scores are rarely useful in assessing quality of the instructional product, so wherever possible attitudinal data should be collected from instruments and methods designed specifically to evaluate the instruction under development.

Calculating the costs of development and the estimated operation costs is usually the final component of summative evaluation. The purpose of this evaluation is to determine the "cost effectiveness" of the product (Coffarella, 1975). The real costs of the instructional development are derived not only from the direct expenses of development but also from the expected life of the product and the level of student learning (Wilkinson, 1972). For example, an instructional product that may be considered expensive to develop might result in better learner performance than a less expensive product. The formulas available to calculate cost effectiveness have become increasingly sophisticated as most institutions have had to justify the high costs of initial development (Roid, 1974). Documentation of costs should be provided in as much detail as possible, the same as for the other data collected in the summative evaluation. This would make it possible for a potential user to examine the costs and interpret it according to his or her own perspective, just as he or she would interpret the learning effectiveness data. Amortization of costs should always be a factor in cost evaluation. Instructional development costs are initially high and can be absorbed over the expected shelf life of the product or if sold commercially, by the number of units sold.

Product

At the conclusion of the production phase, the instructional materials can be put to use in the learning environment. In addition to the instructional materials a final development product should be the technical report. Just as researchers must define and elaborate their research methods in written form, so also should developers. Even if we have an incomplete science, we can still document how and why decisions were made, allowing the user the option on acceptability—just as in acceptance or rejection of research.

Implementation Phase

This final phase of instructional development is the implementation of instructional materials in the learning environment. The two parts of this phase involve implementing the instructional materials and managing an evaluation system that maintains the materials in relationship to the total learning environment.

Implementation and Maintenance Evaluation

If a new management system for the learning environment is developed in conjunction with the development of new instructional materials, then the management system should be installed prior to the introduction of the new materials. Davies (1973) maintains that the conditions of the management system need to be operational first to ensure that the various instructional materials components can function to their full capabilities. Too often new instructional materials lose their potential when the management system if not ready.

Evaluation of the learning environment after implementation of new instructional materials can influence the useful life of the materials. Maintaining the materials at or near the original level of effectiveness is the purpose of this final phase of evaluation. One of the first considerations in this area deals with the question: Are the instructional materials still worth using? In other words, do the benefits derived from the product justify the costs? Some of the benefits identified by Silvern (1972) include such factors as learning performance, positive learner attitudes, and efficiency of the materials and the management system. Efficiency of the management system refers in part to the ability of the system to adjust to innovation and updates in the learning environment. An efficient management system should signal change that is required to maintain or even improve the learning environment.

Performance of the students during and after participation in the learning environment is an important source of data for maintenance evaluation. Student performance while in the environment provides immediate information on the degree to which instructional materials enable students to meet the objectives of the instruction. There are, however, two additional sources of data which can be used in this evaluation. They come from curriculum evaluation models and are usually referenced in connection with needs assessment procedures (Provus, 1971). The first is student performance in the succeeding instructional materials (that is, is the student acquiring the appropriate behaviors necessary for entrance into the succeeding instruction?). The second is student performance after transferring into a noninstructional environment (that is, is the instruction meeting the curriculum goals?).

Student attitudes toward the instruction may fluctuate according to changes in the student population. It is probable that student imposed instructional changes may occur if students enter instruction with different prerequisite skills and backgrounds than were anticipated during its development. Instruction itself can cause a negative student attitude if there are out-of-date visuals, poor photographic displays (for example, films and film strips), missing resource materials, or any other components of the system which do not meet the technical standards of the original product (Davies, 1973).

Another form of maintenance evaluation involves the updating of the content to keep the instructional materials current. Certain disciplines or subject matter areas are more susceptible to change than others; however, the user should establish and follow procedures to review the content for any possible changes. It is good evaluation practice to assume that changes will occur and that periodic changes in the developed instructional materials will be necessary. Likewise, the behaviors required in relation to the content should be reviewed for possible updating.

With the increased use of technology in learning environments, the technology must be evaluated and maintained as well as the courseware and software. Where possible, new media resources should be incorporated into the system to add to the management or delivery systems and to improve the efficiency and even the effectiveness of the learning.

Conclusion

The instructional development model described in this paper was deliberately constructed to eliminate the boxes and arrows commonly used to illustrate how development works. Many of my colleagues and training associates view this as a maturing of the field. Just as computer scientists have all but eliminated the flowchart from the programing process—a result caused by sophistication of ideas and operations—so instructional developers are establishing conceptual systems that cannot simply be reduced to several boxes with connecting lines and arrows. A well-organized development system would be too complex to diagram, and if it were diagramed, no one could follow it.

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