

CHAPTER III

SYSTEMS DEVELOPMENT

Instructional Systems Development is an organized set of procedures for establishing goals and objectives, developing plans for their implementation, and evaluating the extent of their actualization. Systems development received great impetus in the research and development work sponsored by the Government. E.V. Saul has written:

Our experience indicates that Government and government-sponsored agencies are the most productive of systematic research and application in this area (human learning and education): in the U.S. special mention may be made of the U.S.A.F. Personnel and Training Research Center, Lackland Air Force Base, Texas; the Human Resources Research Office, Washington University, D.C. the U.S.N. Office of Naval Research, Washington, D.C. and the U.S. Naval Training Devices Center, Port Washington, Long Island (Saul, 1959, p.180-182).

In reviewing this work Robert Glaser noted:

The Human Resources Research Office is essentially the training research and development arm of the Chief of Army Research and Development and it has been in operation since 1951. In 1963 this organization employed one hundred psychologists (sixty-five Ph.D.'s) and consisted of a headquarters and seven major laboratories. The Air Force Personnel and Training Research Center... in 1956... employed approximately 168 psychologists (one hundred Ph.D.'s) and consisted of a headquarters and nine major laboratories plus a network of field units (Glaser, 1964, p.159,161).

Glaser found several steps that the military research contributed to the designing of instructional systems.

A first step in designing an instructional system is the specification of its purposes and the objectives to be achieved. When the literature reflecting work in the military is examined, it is evident that a concern of experimental psychologists who have turned their attention to training research is the lack of explicit specification of behavior under consideration. Many reports express

a concern with the problem of and techniques for defining training objectives.

...A primary example of the analysis of instructional goals is the notions of task analysis developed in the military context by Miller (1953). Such procedures should provide information to assist the designer of a course of instruction in making design decisions (Glaser, 1964, p.154-155).

About this, Meredith P. Crawford has commented that "...perhaps the most important single contribution to the development of training through research has been the determination of methods for the formulation of objectives of instruction (Crawford, 1962, p.326)."

Glaser has pointed out:

The important implication for educational practice is the need for the development of techniques for the analysis of what the student needs to achieve. On the basis of the behavioral specification of the end results of the school environment, achievement tests can be constructed, teaching and research in instruction can proceed, and curricula can be designed (Glaser, 1964, p.156).

Furthermore,

In the military services and in industry, increasing attention has been paid to the determination of the best combination of instructional objectives, entering-behavior (aptitude, achievement, and background) requirements, and instructional procedures in order to achieve over-all organizational goals with maximum utility.

...Work in this context has prompted consideration of the relationships among aptitude measurement, training, and achievement...The classes of variables described are previous achievement, prerequisites for learning, learning sets, ability to make necessary discriminations, and learning motivation (Ibid. p.157-158).

Finally,

Major emphasis in military training programs has been placed on the construction of evaluative measures for assessing the outcomes of training...This effort has been stimulated by the need for an answer to the question, "Does training produce the goals that it is established to produce (Ibid. p.166)?"

Altogether, then, this training research has resulted in a

procedural sequence. Briefly, the steps are: 1) specification of purposes, 2) conducting a needs analysis, 3) task analysis, 4) specification of instructional objectives in behavioral terms, 5) measurement of entering behavior, 6) development of instruction, and 7) evaluation.

Many writers have elaborated on the various steps in this instructional development sequence (Paulson, Nelson, Twelker, Hamreus, 1969; Ammerman and Melching, 1966; Glaser, 1965; Mager, 1962; Smith, 1966; Gilbert, 1962; Gagne, 1964; Allan, 1973).

Goals and Objectives

The CORD National Research Training Manual (2nd ed. 1969) summarizes the basic steps in instructional systems development. The authors, Nelson and Paulson, state that the first step is to establish a philosophy and broad goals.

Careful definition of...philosophy establishes the parameters of the value system within which all aims and objectives of the educational program are to have relevance and typical values against which they will be evaluated (Nelson and Paulson, 1969, p.I-6).

Nelson and Paulson distinguish between goals and objectives in the following way:

Objectives, as compared to goals, are relatively explicit formulations of the ways in which students are expected to change within the education process (Ibid.).

Richard Allan (1972) refers to broad goals as "purposes." He suggests that establishment of a general purpose should be followed by a needs analysis. By this, he means research to discover what is needed to satisfy the accomplishment of the purpose. From the results of this research, it should be

possible to subdivide the goal into specific objectives.

Basically, the needs analysis should consider five areas. ...the broad categories to consider should include student characteristics, student interests, community characteristics, review of literature by subject matter experts, and opinions and experiences of participating teachers (Allan, Gorth, O'Reilly, 1972).

The needs analysis is followed by a task analysis.

The basic question that one asks when embarking upon a process of task analysis is: What does a student need to know and to be able to do in order to attain the final criterion level established for this instructional unit (Nelson and Paulson, 1969, p.I-25)?

Two further questions are:

1. What is relevant to the intended performance situation. That is, what are the skills and knowledge that are likely to be useful in anticipated situations.
2. What is critical to instruction? Here one needs to identify the skills and knowledges that are most likely to be needed; those for which instruction in the program is most necessary (Ibid. p.I-26).

Nelson and Paulson suggest:

...if one can observe a variety of unsuccessful performances the various reasons for their being unsatisfactory may suggest a variety of behavioral components required for successful performance. By thus breaking down one complex behavior into a number of simpler behaviors, the planning and development of an instructional system may be enhanced considerably (Ibid. p. I-27).

In brief review, then, the Instructional Systems Development Sequence begins with a clarification of philosophy, statement of purpose or goal, and proceeds with an analysis of the educational needs specification of the components required for fulfillment of the needs.

Next, each of the components can be written down in specific behavioral form (behavioral objectives). Usually, a behavioral objective is written in such a way that it states a

condition, a behavior, and a standard (Mager, 1962; Allen, 1972; Nelson and Paulson, 1969). In other words, an attempt is made to specify the situation in which a student is to perform, the observable behavior that is to be demonstrated, and the criterion by which the performance will be judged. One method of writing behavioral objectives, by Gronlund (1970), is presented in the appendix. Gronlund emphasizes that behavioral objectives should focus on what the student is to be able to do rather than on what the teacher does.

Behavioral objectives can be derived from the task analysis. In studying the task analysis it is usually discovered that some objectives can be grouped in hierarchies. The most inclusive objective at the top of the hierarchy is called a "Terminal Objective," while the other objectives are called "enabling objectives" (Nelson and Paulson, 1969).

Once these objectives have been formulated, instruments can be made which test the students' abilities to perform the behaviors to the standard stated, under the conditions listed. These kinds of tests are called criterion-referenced tests (Allan, Gorth, O'Reilly, 1972).

Development of the Instructional System

Once specific objectives have been stated it is necessary to establish methods for carrying them out and evaluating their attainment. This step is called development of instructional systems design. Paul Twelker (1969) has presented an "exhaustive check list" for designing an instructional system. Twelker's steps are as follows:

1. Identify learner characteristics. This maximizes the adaption of instruction to the learner's personal needs, and reduces the chance of the system simply becoming a slick "Madison Avenue" package.
 2. Identify tentatively the general characteristics of the instructional system to be used to achieve the terminal objective(s). That is, attempt to look at the whole system and outline its characteristics.
 3. Identify tentatively the relationship between, and general characteristics of, the way in which en route objectives in the instructional system will be taught. This lets the designer match his tentative overall specifications for the system with each objective in the system.
 4. Then, for each en route competency, identify the type of learning function represented. Is it problem-solving or multiple discrimination or something else?
 5. Identify the instructional strategies that provide general conditions of learning. If general principles are identified.
 6. Specify the learner response(s). What is the learner supposed to do? What is the form of the response? What media are required?
 7. Specify the stimulus situation. What is the occasion of exposure to information or orientation? What form does it take? What media are required?
 8. Specify feedback for each instructional event. How are you going to tell the learner that his response is correct? What will you tell him?
 9. Specify the required or permissible context of instruction. In what environment does all this take place?
 10. Specify the appropriate sequence for each instructional component to ensure optimal mediational effects from one component (i.e., response, stimulus, or feedback) to another. How responses, stimuli, and feedback are put together can't be ignored.
- For each instructional sub-system and instructional system as a whole:
11. Specify the required or permissible context of instruction, considering the relationships and specifications previously identified. Now that the instructional conditions for each objective have been specified, take a new look at the tentative specifications listed from Step 2 and 3. Adjust accordingly.
 12. Specify the appropriate sequence of all instructional units to ensure optimal mediational effects from one unit and one sub-system to another (Twelker, 1969, pp. II-28, 29, 30).

Chapter IV of this dissertation is devoted to elaborating each of the above steps in more detail.

Evaluation

After an instructional system has been designed and implemented, a teacher needs to be able to evaluate the whole program to determine what needs to be changed, modified, or retained.

Paulson (1969) defines evaluation as the examination of certain objects and events in the light of certain value standards for the collection of information for the purpose of making adaptive decisions (p. IV-1).

Michael Scriven claims that the goal of evaluation is to attempt

...to answer certain types of questions about certain entities. The entities are the various educational "instruments" (processes, personnel, procedures, programs, etc.) (Scriven, 1967, p.40).

Scriven points out that evaluation must include "...the measuring of performance against goals," and "...procedures for the evaluation of the goals (Ibid., p.52)."

Generally, evaluation has been classified into three kinds; diagnostic, formative, and summative.

Evaluation which takes place prior to beginning a unit of instruction is called diagnostic evaluation or often simply diagnosis. Such pre-instructional evaluation can help teachers obtain information as to what kinds of attitudes, skills, and knowledge students already possess that will encourage, limit, or prevent teacher and student efforts to achieve desired objectives.

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Diagnostic evaluation can also occur during a unit of instruction. The use of diagnostic tools during instruction can help teachers determine the degree to which certain non-instructional factors, such as attitudes toward the teacher, personal habits, relationships with parents, or peer rivalry are affecting student progress toward attaining desired objectives (Fraenkel, 1973, pp.54,55).

Diagnostic evaluation is considered different from formative evaluation, which is defined as follows:

Formative evaluation is evaluation that also is conducted during (rather than before or after) a unit of instruction, but with a different purpose in mind. The purpose of formative evaluation is to help teachers determine how well students are progressing toward attaining desired objectives, and provide teachers and learners with specific feedback as to the degree to which students have mastered certain skills or knowledge studied or presented up to this point, and if they are not understanding the materials, to pinpoint exactly where in a unit they are having difficulty.

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Diagnostic evaluation is most helpful in obtaining insight into rather general skills, attitudes, and characteristics of students, such as how students feel about activities which occur in the classroom, or inter-student perceptions and power relationships. Formative evaluation, on the other hand, is designed specifically for a particular unit of instruction and is intended to locate exactly where in the unit the student is experiencing difficulty (Ibid. pp.56, 57).

Summative evaluation, on the other hand, occurs

...at the end of a unit of instruction in order to determine how much and how well students have learned and to what extent desired objectives have been attained (Ibid.).

Therefore,

Assessment of student attitude, progress, and achievement needs to occur before, during and after instruction, using a variety of evaluative devices and procedures (Ibid.).

This means, according to Stake (1967), information concerning "Antecedent, "Transaction," and "Outcome" conditions is required. Antecedent conditions are:

...all the responses that are carried to the educational situation by the student and teacher participants and which may have an effect on the outcomes (Payette and Cox, 1969, p.209).

Transaction conditions are the attitudes, feelings, and values connected with

...planned interactions among persons in the educational setting for the purpose of achieving educational outcomes (Ibid. p.216).

And, Outcome conditions are

Any modification in the response of participants that can be linked empirically or logically to the educational process (Ibid. p.210).

In using the instructional systems design, outcome conditions can be measured by giving the criterion-referenced-tests.

However, as just pointed out, more information than this is needed. The teacher also needs information about entering behavior and social emotional climate. Furthermore, appropriate-

ness of goals needs to be evaluated. A teacher needs to know what to eliminate and what to add, how effective the materials and presentations were, why certain students did not learn, what items they had difficulty with, how complete the needs and task analyses were, whether the test items actually tested the objectives, whether learning steps were too small or large, whether students like the program, if the program is attention getting, what the quality of interaction is, if there has been a change in attitude about the topic, whether the instruction spurs growth, whether the environment is nourishing, and if the pacing is appropriate so that each student is progressing as fast as he should.

This means information must be collected on individual students, the group as a whole, the instructional plans and goals, and the materials, media, and presentations.

In looking at an individual's learning, a teacher must discover:

What has a student learned?
What does a student already know?
How much does the student retain? (Gorth, Allan, O'Reilly, 1972)

These questions are necessary to know:

- 1) where in the instructional sequence to start the student...
- 2) whether to move on to learn future objectives or whether review or more depth is required on the objective just taught; or
- 3) whether forgetting is taking place over time which may necessitate reviews on an objective long after it has been taught (Ibid.)

In gathering information about groups teachers need to know:

- 1) Are problems of group integration and group functioning minimized?
- 2) Are group members provided with enough opportunities to interact and communicate in, and are they establishing satisfactory, fully functioning classroom organization?
- 3) Are class members involved in solving problems of particular concern to them and given opportunities to increase feelings of security, confidence, and self-esteem by using their interpersonal skills to improve working conditions?
- 4) Can the group cope positively with confusion, tension, and pressure by recognizing it and reducing it?
- 5) Is there a high degree of trust and confidence in the classroom group so that individuals feel comfortable functioning in it? (Bany and Johnson, 1970, p.409-410).

In order to determine these things a teacher must know how to get the information. Data gathering will involve measurement, testing, and observation.

Measurement is the process of using a test, scale, or instrument to obtain a relatively objective and quantified indication of a person's standing on a characteristic represented by the device employed.

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A test may be viewed as a collection of tasks, better known as items or questions, each of which is a sample of some domain or behavior.
.....

Observation differs from testing as a measurement procedure in that customarily the teacher or another professional person...focuses his attention upon certain segments of student behavior and systematically records his perceptions or impressions (Wilson, Robeck, Michael, 1971, pp.456, 466, 467).

Therefore, a test is a tool for gathering information through measurement. Measurement is the placing of a value relationship on the information. Observation is another kind of tool (besides testing) for gathering information.

Different kinds of testing and measurement have been developed to get at different kinds of information. Two kinds of testing are 1) norm-referenced testing and 2) criterion-referenced testing. Criterion-referenced tests are:

...tests which contain only items related directly to previously stated behavioral objectives...which are used to measure whether students can or cannot accomplish the behavior stated in the objectives (Allan and Gorth, 1972)

Norm-referenced tests are:

...tests which are not necessarily related to behavioral objectives (and which are)...constructed to show the standing of an individual in relation to others in the group of those being tested (Ibid.)

CAM (Comprehensive Achievement Monitoring) is one criterion-referenced testing evaluation system that has been developed (Ibid.)

It is called a "comprehensive" achievement monitoring system because the information provided on each student in the class, and on the entire class as an entity, is far more extensive than the information provided by the usual types of teacher made classroom tests (Ibid.).

The CAM system collects data on all behavioral objectives every two, three, or four weeks in order

...to provide the teacher with detailed information on how well his/her course is going (what percentage of the students are able to answer test items on each course

objective) and how well each student is doing (which objectives can each individual student master).

This is like giving a final exam every two or three weeks. The reason for this is to see (1) which objectives are already known before they are taught, (2) how well objectives just taught were learned, and (3) how well objectives taught earlier in the course are remembered. Also, it is possible to begin plotting trends in the data. CAM is more than just the theory presented, however. The statistical foundations have been carefully worked out so that data provided by CAM is adequate for making decisions. Computer programs are available to take all the data received from student answer sheets and do all of the mathematical calculations necessary to make this data meaningful to students, teachers, and administrators. Also, forms have been developed so that the data are clear to students (they receive a student report) and teachers/administrators (they receive a teacher report and class summary) (Ibid.).

Another form of testing is Mastery testing which uses a pre-test before instruction and a post-test after instruction to check the change that has taken place during the time of instruction.

Metfessel and Michael (1967) have listed over 80 different criterion measures that can be used in evaluating different characteristics of objectives of a program. This list is presented in the appendix.

All tests should possess a number of basic characteristics. Validity, Reliability, and Objectivity are the most important.

The usual definition of a valid test is that it measures what it is supposed to measure.

A reliable test is consistent--that is, if it is repeated, students score roughly the same as they did the first time they took the test.

Objectivity refers to the absence of subjective judgments. It is very difficult to attain, and is probably never attained completely (Fraenkel, 1973, pp. 280, 281, 284).

There are a few important rules of test-making. Some are:

- 1) Be clear as to the purpose of your test.
- 2) Plan...the proportion of different kinds of questions you will ask.
- 3) If your purpose is...diagnosing a basic skill...prepare at least ten questions...on each skill you are assessing.
- 4) If your purpose is...diagnosing individual strengths and weaknesses in a particular skill...prepare at least ten questions on each aspect of the skill that students must master in order to attain the skill as a whole.
- 5) If your purpose is primarily one of determining how well your class has mastered a particular set of objectives, you should develop a test that parallels work in class.
- 6) If your purpose is primarily one of ranking students in the order of their achievement, your questions should focus on the "critical" points of learning.
 -write your items in language that students can easily understand.
 - Be sure that there can be only one interpretation to your question.
 - State the question in enough detail so that students understand what is expected of them (Ibid. pp.284,285, 286,291,294).

The differences and similarities between objective and essay tests and the conditions under which each should be used are summarized by Ebel (1969) and can be found in the appendix of this dissertation. The appendix also contains some sample instruments which can be used for measuring "entering behavior." Evaluation, then, is

...a process of examining certain objects and events in the light of specified value standards for the purpose of making adaptive decisions (Paulson, 1970, p.1).

An assessment "...needs to occur before, during, and after instruction, using a variety of evaluative tools (Fraenkel, 1973, p.58)." And, such tools need to be checked for validity, reliability, and objectivity.

As can be seen, therefore, evaluation is a very important aspect of the instructional systems design. In review, the systems sequence is composed of: 1) purpose, 2) needs and task analysis, 3) behavioral objectives and criterion-referenced tests, 4) assessment of entering-behavior, 5) designing instructional environments, and 6) validating tests and evaluating total program.