The Process of Task Analysis

Integrating Training's Multiple Methods

Kenneth E. Carlisle, Ed.D.
Nuclear Training Analyst
Palo Verde Nuclear Generating Station
Arizona Public Service Company
Phoenix, AZ 85033

Task Analysis: The term conjures up a magic solution for many training problems. Adherents point out that task analysis can ensure the following advantages (Gibbons, 1980):

- Identification of the full set of training requirements.
- Elimination of unnecessary training.
- Learning and retention efficiency by virtue of logically ordered and organized instruction.
- Improvement of communication within the training development team.
- Reduction in training costs and inadequate job performance.

The advantages of task analysis do seem impressive; however, there are serious problems involved with its implementation. One of these problems concerns definition. There is little consensus about what the term "task analysis" means or how the analysis should be done. Indeed it seems to mean neither more nor less than the person using it wants it to mean. Lack of consensus on definition is a characteristic of underdeveloped technologies which certainly applies to task analysis (Bernard, 1975). It would seem difficult to consistently achieve the stated advantages of task analysis when little consensus exists concerning what it is and how it should be used.

This paper presents one perspective for defining the process of task analysis and then discusses how various techniques of analysis relate to this perspective. This integration of definition and analysis techniques is essential because training problems are solved by careful analysis, not by undefined and unintegrated task analysis.

Task Analysis: A Process Definition

What are task analysts trying to do when they examine an area of human performance? The answer to the question cuts to the heart of this definitional problem. Task analysts describe a task in terms of its component subtasks in order to make prediction about the design which will best reduce error in human performance (Davies, 1973a). Ideally, this analysis suggests both how to perform the task correctly and how to instruct a person to perform the task.

The methods applied to describe performance and instruction all use essentially the following process (Patrick & Stammers, 1978; Carlisle, 1982b, 1983):

1. Break the task, content, etc., down into constituent elements.
2. Determine the relationships among these elements.
3. Restructure in accordance with the underlying principle or optimal learning design. (Note 1)

Task analysis may be more properly defined as a process involving these three steps. Different techniques of analysis may be used in different situations for different purposes to describe or design elements of accomplishments and acquisition. These different techniques, however, either follow all or part of the task analysis process, or provide the structure necessary to initiate or complete the task analysis process. For instance, the process of recognizing a potential problem and formulating a deviation statement is one analysis technique which may initiate a task analysis. Analysis of risk may be done to indicate the completion of a task analysis step. These are decision oriented techniques which are integrated with other analysis methods to follow the complete process of task analysis. There is no single technique of task analysis; rather, there are many techniques which contribute to the complete task analysis process.

One final implication of process definition is that the task analysis is not complete until all of the steps are followed. Analysis which stops short of completion often results in bulky documents which remain unused (Carlisle, 1983). However, when all analysis steps are completed in a useable form (for example, a job aid) the results will have immediate impact on training and the work place.

It is recognized that the process definition broadens the view which some have of task analysis. Some feel that task analysis should only be used to refer to the breaking down of performances into component parts (Kaufman and Mitchell, 1982). Others refer to the restructuring step (Miller, 1962). In this sense the term "task analysis" is unfortunate (Davies, 1973b) because the three process steps previously described can be used to analyze tasks from many points of view, for example, the required content, the knowledge involved, the condition of learning, the required skills, and required algorithmic or heuristic processes (Landa, 1982). Alternatively, the broad process definition offered here might be termed something like "predevelopment analysis" (Gibbons, 1980) or "training analysis" since needs analysis and goal definition are intimately involved throughout the process. For the purposes of this paper, however, the traditional term "tasks analysis" will be retained.

With this perspective in mind, we will examine how task analysis techniques might be most effectively combined and used to break the task down, examine relationships, and restructure for performance and instruction.

Step One: Breaking the Task Down

Task breakdown begins with the initial definition of the analysis situation. This definition specifies what should be analyzed, when it should be analyzed, and where it can be analyzed. The following categories may be found in this definition:

- Deviation statement showing what should exist and what currently exists relative to the task.
- General description of the job, duty, or task to be analyzed with references to available job documentation.
- Description of the workers who will perform the task.
- Description of the expected benefits to be realized from the analysis.
- Description of maximum cost to be incurred.
- Description of the preferred format for analysis outcomes.

Once the area of analysis is defined, the analyst breaks the task down with the intention of describing current job and task performance, i.e., how the task is now performed. This breakdown begins with a listing of jobs or tasks—the job/task inventory (McCormick, 1979)— consisting of basic performance objectives for all duties of job. It is developed from available documentation as well as observations, interviews, questionnaires, or brainstorming sessions with master job performers. From this inventory it is possible to determine which duties require more detailed description by using the following questions to assess the risk of error associated with each duty:

- What is the possibility of an error resulting from this task?
- What are the consequences to safety, cost, public relations, etc., if an error does occur?

The answers to these questions make it possible to select tasks for additional description, since a task with high probability of error and high costs needs additional analysis, whereas low probability and cost mean no additional analysis is necessary. Figure 1 summarizes these decisions.

Additional information might be asked about each task to determine if more detailed description is required. These include performer's characteristics, difficulty of performing or learning the task, importance of the task, performance frequency, number of people involved, time required to perform, where the task is learned, supervision required, and satisfaction gained during performance. This additional information is helpful during the later task analysis steps, but emphasis should be on the probability and consequence of error during task breakdown, since the most critical elements of some jobs (airplane pilots, nuclear power plant operators) are infrequently performed, require little time, and are performed by only a few individuals.

Tasks which require more detailed analysis are then subjected to hierarchical redescription. This hierarchical analysis is used to identify the specific elements underlying the job. The analyst continually iterates the question "How does one do this job?" or "What does this job consist of?" The job is broken down into related duties which are subsequently divided into related elements, and finally into specific motions or procedures. Analysis stops when the possibility and costs of an error for each task or element are acceptable, entry behaviors are identified, or the task is described sufficiently to move to the next step in the process. The technique of hierarchical redescription described by Duncan (1972) and Shepherd (1976) provides one concise format for recording this analysis. It includes the superordinate number, the task component and operation plan, and the reason for stopping analysis.

The Job Analysis Brainstorming Session (JABS) (McDermott, 1982), another method for organizing the process of creating the hierarchy, posts 3x5 cards of master performers' job descriptions on a blank wall. The 3x5 cards show the flow of task performance including alternative descriptions of what is done when something goes wrong with the normal flow of performance.

The initial breakdown describing how the task is currently done may result is very specific task detailing which may be formatted as column charts (Miller, 1962), motion charts, (Seymore, 1968), or flow charts (Merrill, 1980b). Often, however, great detail is not required during this first step because the intent is to provide only enough description to determine likely performance errors and task changes needed to avoid error. Over analysis during this first step often occurs when the actual goal, to organize improved performance, is not stressed. The analyst is not interested during this first step in describing those tasks where errors are likely. The analyst should therefore move to the second task analysis step (relationship determination) as soon as possible.

Step Two: Looking at Relationships

The second step in the task analysis process is examining the relationship between the task as it is currently done and how it should, or could be done. The intent is to identify how the task

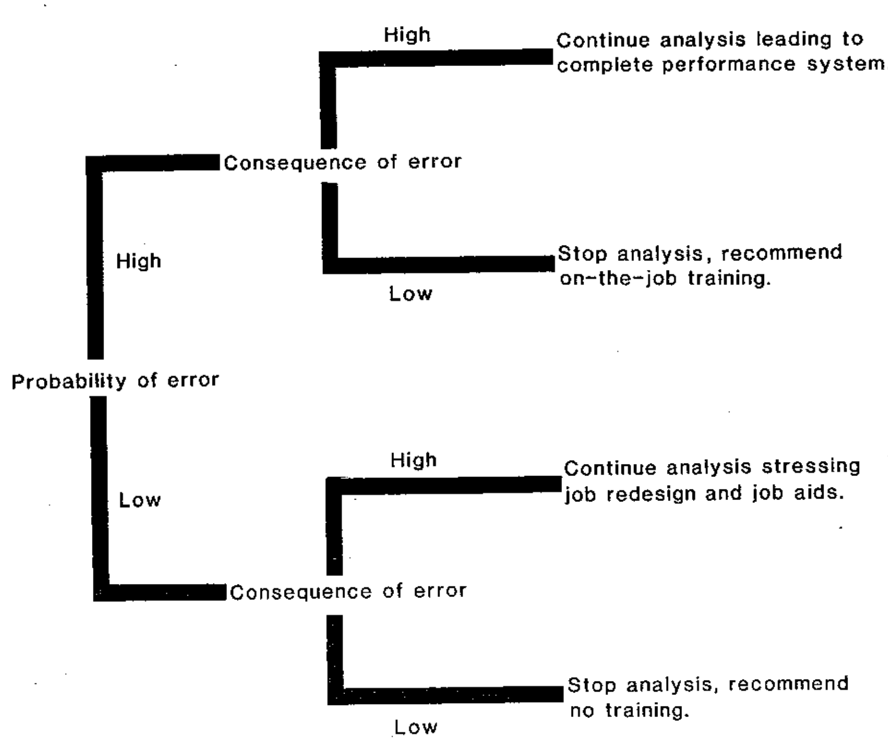

Figure 1. Decisions associated with probability and consequence of error.

could be changed to remove performance error from the following outcome measures (Jackson and Bullock, 1983):

- Results or effects as indicated by task accomplishment and consumer satisfaction.
- Quantity as indicated by how much of the output is produced.
- Quality as indicated by how well accuracy, completeness, costs, timeliness, and safety are provided in the output.

Four approaches can be used to examine relationships. The existing task might be compared to a predetermined model of correct performance. Different methods of task performance might be compared. Portions of the task that are not effected by performance error might be compared to portions that contain error. Finally, comparisons can be made between individual task components. These approaches are often used in an iterative manner with task breakdown. For instance, a comparison with a predetermined model may indicate the need for a more detailed task breakdown, which may be followed by a comparison with different methods of task performance, which may require additional breakdown.

Behavioral analysis and visionary analysis both suggest models of correct task performance for comparison with the actual task to identify performance error. Behavioral analysis is based upon the systems model or the behavioral model. The input cues encountered, operation performed, information needed, objects used, time involved, decisions required, results and feedback given, and motivations involved are recorded. This information is used to identify performance errors. Three types of error might be found (Duncan, 1972; Reason, 1977; Davies, 1981).

- *Input errors*—those resulting from failure to discriminate a signal or cue leading to an action. The outcome is inappropriate action (also called selection errors or discrimination errors). These are often caused by poor delivery systems that give the wrong information, unorganized information, or poorly timed information.
- *Process errors*—those resulting from neglecting or forgetting a goal, sequence of actions, or piece of essential information (also called response errors, storage errors, or action errors). These are often caused by poor job design, inappropriate tools and equipment, lack of knowledge, or poor motivation.
- *Feedback errors*—those resulting from a faulty verification or checkout of a process, for example, the task is terminated prematurely or continued beyond what is necessary (also called output errors or test errors). These result when consequences and feedback are inconsistent, inappropriate, partially given, incorrect, given for the wrong reason, or given at the wrong time.

The PROBE model (Gilbert, 1982a, 1982b) is probably the most detailed behavioral analysis technique. This model identifies the information, instrumentation, and motivation found in the behavioral environment and in the person's repertory. The categories of this model are compared to actual task performance using suggested questions to identify where task errors are likely to occur. The PROBE model includes a precise theory about how to restructure the task to eliminate the identified errors.

There is no single technique of task analysis; rather, there are many techniques which contribute to the complete task analysis process.

Visionary analysis (Note 1) is a recently proposed method for creating a correct model of task performance. Visionary analysis avoids focusing upon the problems in the current task by visualizing or mentally rehearsing ideal methods of task completion. Master performers write down a description of what they see, hear, feel, smell, and taste as they imagine doing this ideal task. As much detail as possible is included about who is doing what, when, where, and how. It is then determined if this description is actually what is wanted, and the description is compared with the current task to determine where modifications should occur.

Critical incident analysis is a second way of examining relationships. It is done by comparing different methods of doing the same task. The following steps are involved in this technique (Zemke, 1981):

1. Master performers select and write job incidents and results which are related to specific tasks.
2. Incidents are reviewed for consensus of the master performers, edited as needed, and labeled for ease in rating.
3. Incidents are sorted on a seven or nine point scale for favorable or unfavorable consequences.
4. Master performers fill any gaps in the scales with additional incidents.

The resulting scale shows how performers with different levels of expertise might execute a given task. This scale can be important when assessing students' entry behaviors.

Problem analysis (Kepner-Tregoe, Inc., 1979) provides a third technique for analyzing relationships. To solve deviations in task performance, this technique utilized the following comparisons:

- What the deviation is versus what it could be but is not.
- Where the deviation is versus where it could be but is not.
- When the deviation occurs versus when it could occur but does not.
- What the extent of the deviation is versus how extensive it could be.

Distinctions between the "is" and "is not" categories are identified and any recent changes in task performance are examined. These distinctions and changes lead to hypotheses which are compared with the task description to identify when errors are occurring in the task.

A final approach to examining relationships, network matrix analysis, is used to investigate the sequences and patterns of the task. Network matrix analysis begins with a path analysis (Merrill, 1980a) of the task flow or content outline. It then examines these paths to determine the type of relationship between closely sequenced elements and those which are not closely sequenced. Each element is compared with every other element. Those with immediate or simple relationships are naturally placed closer together than those which are related through more complex paths. To improve relationships within elements, revisions are made when gaps, omissions, ambiguities, and areas of inadequate feedback are identified. The method of matrix analysis described by Davies (1973b) is one example of this technique. Cognitive mapping (Diekhoff and Diekhoff, 1982) is another example. Concept hierarchies, algorithms, and heuristic analyses also apply (Landa, 1982).

Application of these methods to computer assisted instruction where a matrix of relations is used to call up different tasks shows great promise for the future.

In current practice, analysts often use only one method of relationship determination when analyzing an individual task. This is perhaps inappropriate. The use of various techniques combined with additional task breakdown, rather than dependence upon a single method, would give a better understanding of the relationships involved in any given task. Task analysis methodology would certainly be improved if analysts made an effort to combine these different methods before moving to task restructuring.

Step Three: Restructuring in Accordance with the Underlying Principle or Optimal Learning Design

Once the task has been sufficiently described and analyzed for relationships, restructuring for correct accomplishment and learning can be done more easily and exactingly. A more detailed description of the improved task should be completed using the results from the previous analysis to develop a job aid (McCormick, 1979), for example, flow chart, checklist, worksheet, decision tree, or decision table. The job aid might be used by employees during task performance, it might be used by designers to change the equipment or tools, or it might be used by management to change the work environment or incentive system. The job aid describes the plan of correct accomplishment, can actually be used in the workplace, and will either eliminate the need for training or will indicate how the training is to be done.

When training is required to effectively use the job aid, additional analysis techniques are required. The task should be analyzed for required learning strategies. Tasks include procedures describing "how" the task is done which require verbal and motor chain learning strategies. Additionally, the students must learn "what" the task is (concept learning strategy) and "why" the task is done (principle learning strategy) in order to perform correctly. The identification of correct learning strategies leads to the selection of correct teaching tactics and learning consequences as shown in figure 2. Numerous authors have discussed analysis of learning strategies (Davies, 1973b; Merrill & Tennyson, 1977; Reigeluth & Darwazeh, 1982; Carlisle, 1982b).

The use of Gagne's (1977) hierarchical analysis can follow the identification of learning strategies for sequencing elements which must (because of "transfer") be presented in a specific order. One creates this hierarchy by asking the question, "What (skill) should the learner already know how to do and be able to recall when faced with the task of learning the new rule, the absence of which would make it impossible for him to learn the new rule?" Merrill (1980a) has shown how a rigorous hierarchy of this type can be derived when the paths identified with an information processing analysis and path analysis are carefully specified.

Once learning strategies are developed and sequenced, it is finally possible to develop specific training objectives which not only point to specific behaviors which the learners will be expected to perform, but are also actually required by the task. A master design chart (Davies, 1976), like that found in Figure 3, can be developed as a final component of the task analysis to integrate the tasks and objectives into a coordinated curriculum. This coordination is essential because even though objectives have become prominent in training, there is little doubt that these objectives are frequently not actually derived from complete task analysis or integrated into the overall training design. Objectives can be found at the beginning of lesson plans, but one seldom observes their correspondence to task listing, sources of error, important relationships, learning strategies, hierarchical sequencing, or master design charts. This state of affairs exists primarily because the process of task analysis is so often short circuited.

Summary

Task analysis is the key to developing the specifications for performance and instructions in instructional systems design. Task analysis, when considered from a process perspective, involves three steps, each of which can be approached with various analysis techniques. These steps and techniques can be summarized as follows.

Step 1. Break the task, content, etc.,

Select Objective Which Matches Most Closely	Rule
Follow a sequence of steps to do something (HOW)	2
State or list HOW to do something	1
Distinguish or classify WHAT something is	3
State or define WHAT something is	1
Summarize, support, or perform something based upon an understanding of relationships (WHYS) between concepts	4
State WHY something is, or should be done	1

Rule	Learning Strategy	Teaching Tactic	Learning Result
1	Verbal Chain Learning	A. Give overview B. Memorize chain C. Practice chain	A. Practice required B. Easily forgotten C. Little transfer to job
2	Motor Chain Learning	A. Give overview B. Practice task C. Corrective feedback	A. Practice required B. Resistant to forgetting C. Transferred to job D. Verbal chain partially learned
3	Concept and Multiple-discrimination Learning	A. Examples, non-examples B. Distinctive attributes C. Present as group D. Rehearsal, feedback	A. Practice not needed B. Resistant to forgetting (except fine discriminations) C. Transferred to job D. Verbal chain partially learned
4	Principle Learning	A. Test understanding of procedures and concepts B. Examine relationships C. Perform task	A. Practice not needed B. Resistant to forgetting C. Verbal chain partially learned D. Motivation increased

Figure 2. Learning strategy decision table.

down into the constituent elements.

Analysis Techniques:

- Task definition
- Job/task inventory
- Risk assessment
- Hierarchical redescription
- Task detailing

Step 2. Determine the relationship among these elements.

Analysis Techniques:

- Behavioral analysis
- Visionary analysis
- Critical incident analysis
- Problem analysis
- Network matrix analysis

Step 3. Restructure in accordance with the underlying principle or optimal learning design.

Analysis Techniques:

- Job aid development
- Learning strategy analysis
- Learning hierarchy sequencing
- Training objective development
- Master design chart development

Instruction and training are often derived using analysis techniques which follow this process in a haphazard manner. If task analysis is carefully organized and follows the proper steps, it can be used to solve many training problems—not because of some inherent magic, but because of the detailed, careful, integrated analysis involved.

Objective \ Curriculum	Beginning Instructional Design	Advanced Instructional Analysis	Instructional Media Production	Administration of Instructional Resources
Define task analysis.	3	1	1	3
Conduct a complete task analysis.	1	2	1	1
Conduct task analyses integrating various methods.	1	3	0	0
Determine appropriate occasions for task analysis.	2	3	0	3

KEY: 3 = Heavy Emphasis
2 = Major Emphasis
1 = Minor Emphasis
0 = Mentioned, But Not Emphasized

Figure 3. Master design chart.

Reference Note

Springer, J. & Powers, B. *Visionary analysis for project outcome-setting.* Presentation at the 21st Annual NSPI Convention. April 5, 1983.

References

Bernard, M. E. *Task analysis in instructional program development.* Theoretical paper No. 52, Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin. (ERIC Document, ED 114 735).

Carlisle, K. E. The learning strategy technique of task analysis. *NSPI Journal*, 1982, *21* (2), 9-41.

Carlisle, K. E. Improving task analysis in the nuclear utility industry. *NSPI Journal*, 1983, *22(2)*, 8-9; 27.

Davies, I. K. *Task analysis: Some process and content concerns. AVCR*, 1973, *21(1)*, 73-85.

Davies, I. K. *Competency based learning.* New York: McGraw-Hill Book, 1973b.

Davies, I. K. *Objectives in curriculum design.* London: McGraw-Hill Book, 1976.

Diekhoff, G. M., & Diekhoff, K. B. Cognitive maps as a tool in communicating structural knowledge. *Educational Technology*, 1982, *22(4)*, 28-30.

Duncan, K. *Strategies for analysis of a task. In J. Hartley (Ed.), Strategies for programmed instruction: An educational technology.* London, England: Butterworths, 1972.

Gagne, R. M. *The conditions of learning* (3rd ed.). New York: Holt, Rinehart & Winston, 1977.

Gibbons, A. S. Pre-development analysis in military training. *NSPI Journal*, 1980, *19(1)*, 34-42.

Gilbert, T. F. A question of performance—Part I: The PROBE model. Training and Development Journal, 1982, *36(9)*, 21-30.

Gilbert, T. F. A question of performance—Part II: Applying the PROBE model. Training and Development Journal, 1982, *36(10)*, 85-89.

Jackson, S. F. & Bullock, D. H. Job analysis. The Training Consultants' Memo, 1983, 2, 8-9; 1-14.

Kaufman, R. & Mitchell, D. L. Risk and training. *NSPI Journal*, 1982, *21(2)*, 4-7.

Kepner-Tregoe, Inc. Problem analysis and decision making. Princeton, NJ: Author, 1979.

Landa, L. N. The improvement of instruction, learning, and performance. *Educational Technology*, 1982, *22(10)*, 7-12.

McCormick, E. J. Job analysis: Methods and applications. New York: AMACOM, 1979.

McDermott, F. M. Try brainstorming—A quick route to job analysis. *Training/HRD*, 1982, *19(3)*, 38-40.

Merrill, M. D., & Tennyson, R. D. *Teaching concepts: An instructional design guide.* Englewood Cliffs, NJ: Educational Technology Pub., 1977.

Merrill, P. F. Analysis of a procedural task. *NSPI Journal*, 1980, *19(1k)*, 11-15, 26.

Merrill, P. F. Representations for algorithms. NSPI Journal, 1980, *19(8)*, 18-24.

Miller, R. Task description and analysis. In R. M. Gagne (Ed.). Psychological principles in system development. New York: Holt, Rinehart and Winston, 1962.

Patrick, J. & Stammers, R. Analysis for training. In J. Hartley & I. K. Davies (Eds.), *Contributions to an educational technology*, Vol. 2. London: Kogan Page, 1978.

Reason, J. Skill and error in everyday life. In M.J.A. Howe (Ed.), *Adult learning: Psychology research and applications.* New York: John Wiley, 1977.

Reigeluth, C. M. & Darwazeh, A. The elaboration theory's procedure for designing instruction: A conceptual approach. *Journal of Instructional Development*, 1982, *5(3)*, 22-32.

Seymour, W. S. Skills analysis training. London: Sir Isaac Pittman and Sons, 1968.

Shepherd, A. An improved tabular format for task analysis. *Journal of Occupational Psychology*, 1976, *49*, 93-104.

Zemke, R. The critical incident method of analysis. In R. Zemke, L. Standke, & P. Jones, (Eds.), *Designing and delivering cost effective training—And measuring the results.* Minneapolis, MN: Lakewood Pub., 1981.

Reigeluth *(Cont'd from page 30.)*

Analysis Procedure: User's guide. A Final Report submitted to the U.S. Army Training and Doctrine Command, 1981.

Reigeluth, C.M., Merrill, M.D., & Bunderson, C.V. The structure of subject matter content and its instructional design implications. *Instructional Science*, 1978, *7*, 107-126.

Reigeluth, C.M., & Rodgers, C.A. The elaboration theory of instruction. In C.M. Reigeluth (Ed.), *Instructional design theories and models: An overview of their current status.* Hillsdale, NJ: Lawrence Erlbaum Associates, 1983.

Resnick, L.B. Task analysis in instructional design: Some cases from mathematics. In D. Klahr (Ed.), *Cognition and instruction.* New York: John Wiley & Sons, 1976.

Resnick, L.B., & Ford, W.W. The analysis of tasks for instruction: An information-processing approach. In T.A. Brigham & A. C. Catania (Eds.), *Handbook of applied behavior analysis: Social and Instructional Processes.* New York: Irvington Publishers, 1982.

Rumelhart, D.E., & Norman, D.A. Accretion, tuning, and restructuring: Three modes of learning. In J.W. Cotton & R.L. Klatsky (Eds.), *Semantic factors in cognition.* Hillsdale, NJ: Lawrence Erlbaum Associates, 1978.

Sari, I.F., & Reigeluth, C.M. Writing and evaluatory textbooks: Contributions from instructional theory. In D. Jonassen (Ed.), *The technology of text: Principles of structuring, designing, and displaying text.* Englewood Cliffs, NJ: Educational Technology Publications, 1982.

Scandura, J.M. Structural learning and the design of educational materials. *Educational Technology*, August 1973, 7-13.

Scandura, J.M. Instructional strategies based on the structural learning theory. In C.M. Reigeluth (Ed.), *Instructinal design theories and models: An overview of their current status.* Hilldsale, NJ: Lawrence Erlbaum Associates, 1983.

Skinner, B.F. Reflections on a decade of teaching machines. In R. Glaser (Ed.), *Teaching machines and programmed learning, II.* Washington, DC National Education Association, 1965.

Wildman, R.M. Cognitive theory and the design of instruction. *Educational Technology*, 1981, *21*(7), 14-20.

Winn, W. Content structure and cognition in instructional systems. Paper presented at the Annual Convention of Association for Educational Communications and Technology, Kansas City, April, 1978. (ED 151 315).