Instructional Analysis

The Missing Link Between Task Analysis and Objectives

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Abstract. In the design of industrial instruction, it is important to maximize learning and transfer to job performance, while minimizing learning time. Both task analysis and instructional analysis are essential processes for achieving these goals. Task analysis is a tool for understanding and specifying the desired final performance or job. The product of task analysis may be a task list, flowchart, and/or other documentation which describes competent performance. Instructional analysis, as distinct from task analysis, identifies the type(s) of learning involved in acquiring a new performance capability and the structure of that learning in terms of component skills and their relationships. The product of the instructional analysis process is a learning map.

This paper describes the rationale for distinguishing between task analysis and instructional analysis, the contributions that both processes make to the design of instruction, and why one is dependent upon the other. The major functions included in the instructional analysis process are described and illustrated with examples. The benefits of using this approach to achieve effective and efficient instruction are summarized.

Background

Gagné (1974) noted that training designers often fail to distinguish between "job-task analysis" and "training task analysis" as early as 1956. This critical distinction is still ignored, or blurred, by many leading instructional design practitioners in the models they offer to the field, as evidenced by a close look at Gibbons' review of content and task analysis methodologies. Some models (e.g., Davies, 1973) advocate the development of instructional objectives directly from the task analysis, thereby introducing dangers of excess and/or inadequate instruction. Other approaches, for example, Esseff and Esseff (1974), do prescribe separate processes for analysis of the job and analysis of the learning components but oversimplify the relationship between the two processes. More is involved than just rearranging the boxes from a task analysis flowchart to form a learning hierarchy or map! Still others, including Briggs and Wager (1981), merge the two processes into a single design phase. If the instructional analysis is not based on the results of a previously conducted task analysis, the designer cannot systematically insure that the instruction will be job-relevant.

Failure to distinguish between the two types of analysis may stem partly from the frequent application of the term task analysis to both processes. We, therefore, prefer to reserve the term *task analysis* to mean the analysis of a job into its component tasks—what one must do to perform the job. The "job" refers to any performance; it is not limited to performance in one's occupational area. The term *instructional analysis* is more descriptive of the second process, the analysis of a task into its learned components—what one must learn to be able to perform each task.

The model of instructional analysis discussed here is derived from Gagne and Briggs (1979) and Briggs and Wager (1981). It is based on Gagne's taxonomy of learning outcomes and provides a structured and verifiable method for analyzing tasks into learned components. While other models exist for "deriving skills and knowledge" from task analyses, we find this approach most useful because it is based on relevant learning theory; it is efficient to use; and it is particularly appropriate to technical skills learning. There are also some significant payoffs in using this model for designing instruction.

Payoffs of Instructional Analysis

First, the instructional analysis process increases the probability of identifying all learning that is prerequisite to performing a task. Because intellectual skills are hierarchically related, for example, we expect prerequisite rule learning to be identified whenever a problem-solving task is the focus of the analysis. We know to search systematically for all essential rules and, in turn, their underlying concepts. Similarly, because of hierarchical and other supportive relationships within learning maps (the output of instructional analysis), instructional sequencing decisions are facilitated. Also, because types of learning are identified during instructional analysis, the foundation is laid for generating appropriate instructional strategies which correspond to each type of learning.

Another important payoff is the elimination of unnecessary instruction. If skill or knowledge items do not emerge during analysis of the desired goal behaviors, they are not necessary in the instruction. Thus, if "nice-to-know" items are included, it is with the knowledge that they are nonessential.

Finally, by doing instructional analysis as a separate step, the analyst can be optimally effective during task analysis by focusing on performance alone, without confusing it with how the performance is learned.

The Distinction Between Task Analysis and Instructional Analysis

Process and Products

Task Analysis. A task analyst asks the question, "How is this job or function (ideally) *performed*?" and documents the answer in a task list and/or flowchart. The task analysis process identifies all subtasks, information flow, inputs, and decisions required to perform a job. Figure 1 is the flowchart which resulted from a task analysis of the job of "conducting formative evaluation of an instructional product," a job performed by most course developers.

The top row of boxes represents major functions in the process of conducting a formative evaluation. This is a high level of task analysis. The second and third rows are a further breakout, or list of subtasks, for one of the major tasks—"conduct review of content accuracy." Finally, a third level task analysis is presented under the subtask "consolidate feedback." Three unordered activities occur here, whose output is input for "summarize feedback data."

This is, of course, not the only way to conduct formative evaluation, but it represents a consensus among several instructional technologists at Bell Laboratories on how the job is best performed, based on observation and consultation with several practitioners in the field. No attention was given to *learning* during this task analysis; the focus was on how the job is best *performed*.

The flowchart (Figure 1) is an essential part of the instructional analysis process in which the tasks were analyzed in terms of their learning requirements.

Instructional Analysis. Instructional analysis requires a different mental set on the part of the analyst than does task analysis. The question asked is, "What must be *learned* in order for someone to perform this task?"

For an example of instructional analysis and its product, refer again to the job of conducting formative evaluation. Contrast the learning map (Figure 2), the product of instructional analysis, with the flowchart (Figure 1) of the task analysis. Specifically, note that in the task analysis, many subtasks eminate from one major task, "conduct review for content accuracy." Why is the difference so great between the products of two analyses?

From a performance viewpoint, there are many steps involved in the task of conducting a content review. From a *learning* viewpoint, however, none of these steps, or subtasks, would constitute new learning. Members of the target population could, without additional instruction, "identify possible subject matter experts" or "make arrangements for a content review," since these behaviors are already in their repertories. The only new learning that is required here is the concept "content review." If the learners can demonstrate acquisition of this concept, they are, hypothetically, able to apply previously-learned skills and knowledge such as organizing, coordinating, and planning, to the task at hand—"conducting a content review."

The flowchart resulting from the task analysis would not be used box by box, as a basis for developing training objectives, but perhaps as a job aid to prompt learners back on the job as they go through the steps of conducting a content review. It is the learning map, instead, that is the basis for developing training objectives.

Since specific tasks resulting from task analysis are often eliminated as candidates for training via instructional

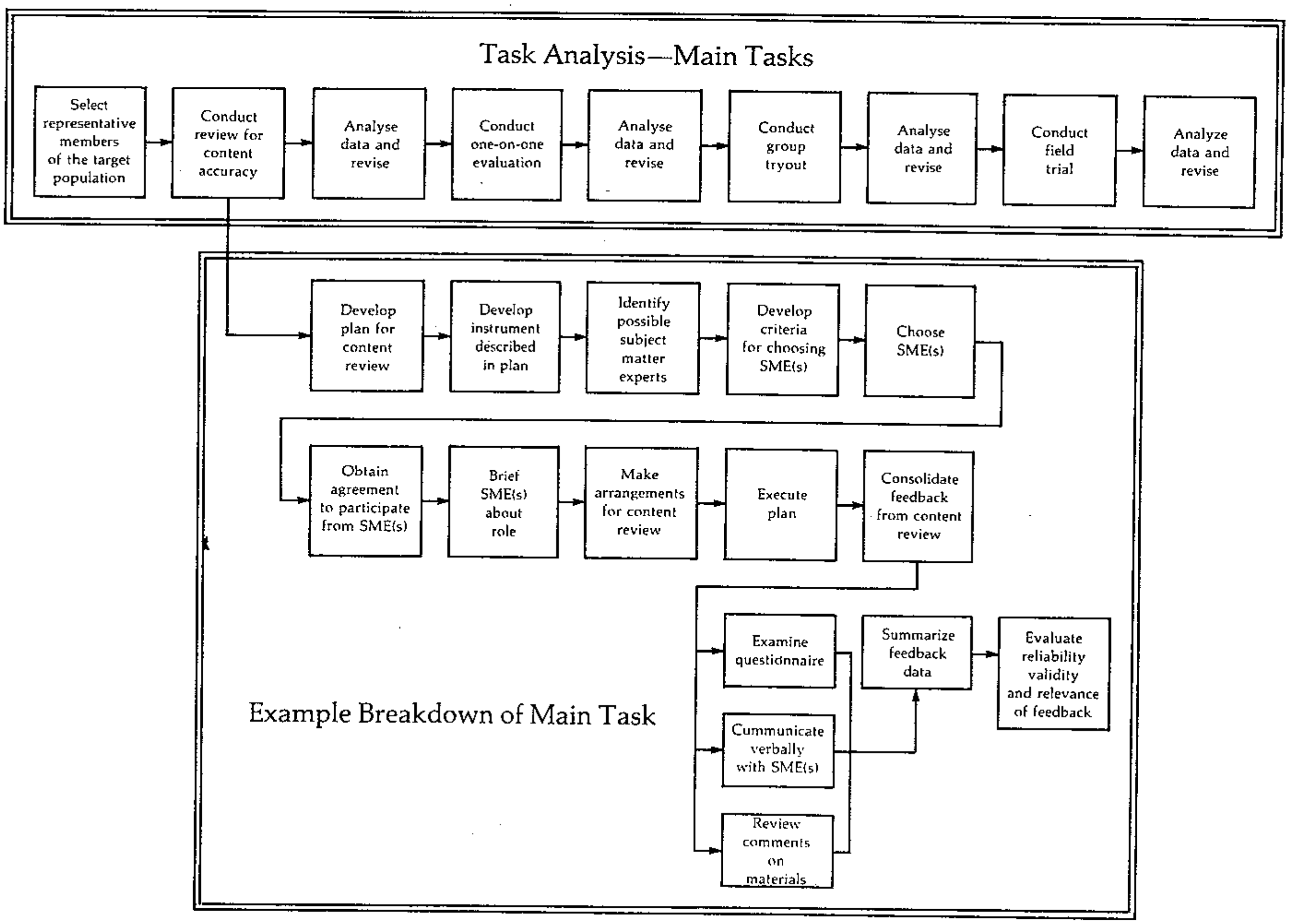
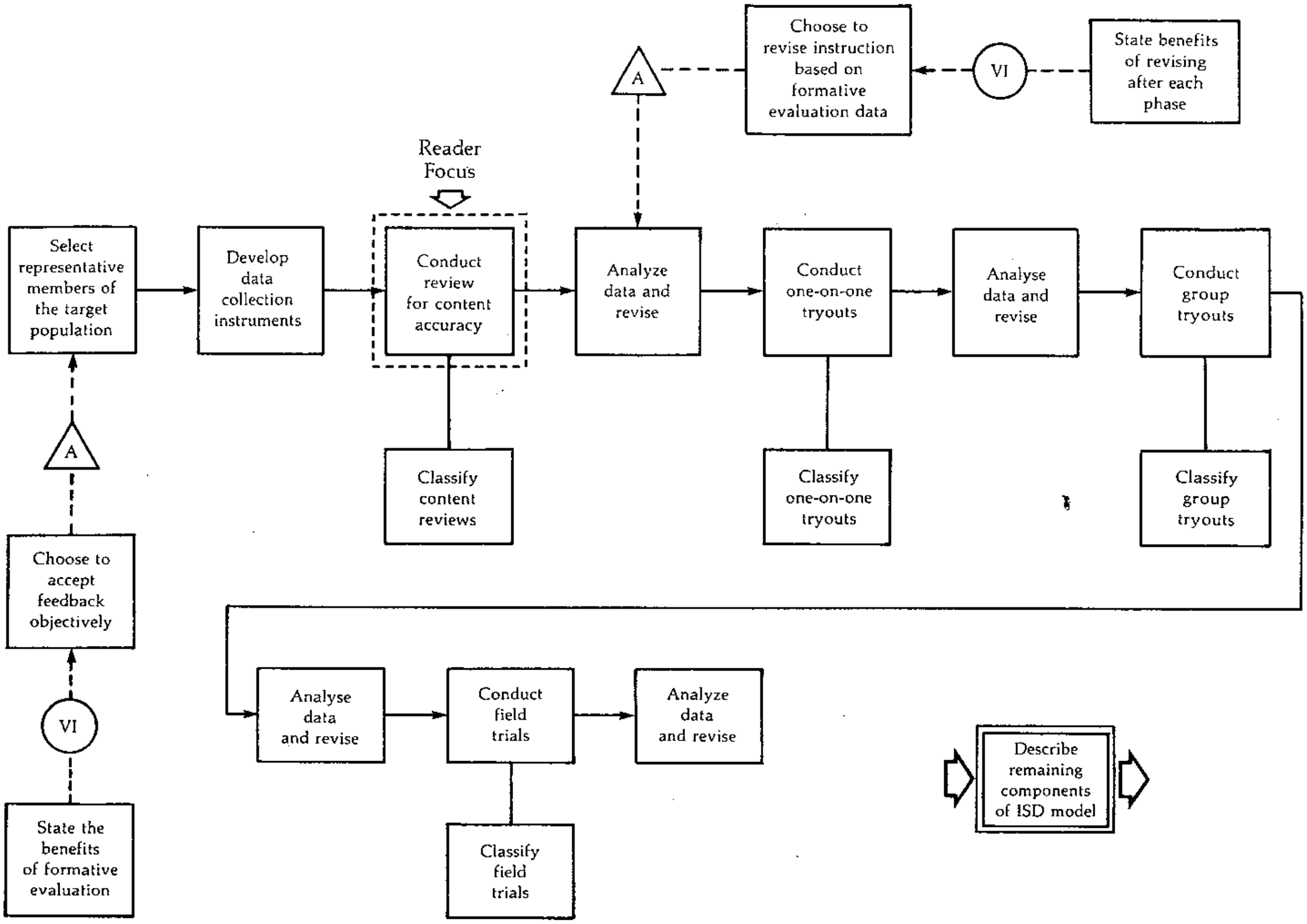


Figure 1. Conduct Formative Evaluation



Note: This learning map illustrates several features of learning maps which are explained later in the paper. The horizontal flow represents learning tasks that are best learned in a linear, left to right sequence, because the order itself is part of the required learning. Boxes below this procedural flow and connected by solid lines represent skills identified as essential prerequisites to their respective superordinate skills. Components connected by dotted arrows are verbal information and attitudes hypothesized to be supportive but nonessential to the learning process. Teaching/learning sequence is only partially dictated by the learning map and is also influenced by strategy decisions made later in the design process.

Figure 2. Conduct Formative Evaluation: Instructional Analysis

analysis, training *efficiency* is often improved with this approach. Training can also be made more *effective* with this approach, since a focus on learning generic concepts and principles will facilitate a whole class of behaviors needed for a job and, therefore, enhance transfer of learning from the training situation to a variety of similar situations on the job. Transfer is less likely to occur when a task is taught simply by exercising its steps in the limited number of contexts available in the training setting.

Conducting Instructional Analysis

We have found the Gagne and Briggs (1979) and Briggs and Wager (1981) approaches to *instructional analysis* to be extremely useful in actual practice. The process described here is an extension of their technique, instructional curriculum mapping. Our approach differs in that we propose the use of a hybrid "type of learning" that can make the instructional analysis process more efficient.

Instructional analysis is not a linear process. It is iterative, as are all processes in systematic instructional design. For simplicity of explanation, it is described here as a linear process (see Figure 3).

Actually, the designer must move artfully back and forth between functions, integrating each of the function outputs with the other, to form the total *learning map*—the product of instructional analysis.

Function: Identify Types of Learning

The instructional analyst first attempts to determine what *types of learning* are required for trainees to acquire the skills necessary to perform the job tasks. This classification by type of learning is required in order to select the most appropriate analysis method(s).

Figure 4 summarizes and briefly defines the five domains of learning identified by Gagne, lists designer verbs associated with each type of learning, and illustrates each with a sample task from a course in Structured Systems Analysis. For complete coverage of these types of learning, see Gagne (1977) or Gagne and Briggs (1979).

In the "conduct formative evaluation" example described above, concept learning was required instead of procedures learning, because members of the target population already knew how to do the separate procedures, but they could only be accomplished competently with acquisition of the underlying concept.

A Hybrid Type of Learning —Complex Procedures

In performing instructional analysis for many of the training development projects at Bell Laboratories, we have found it useful to identify a sixth type of

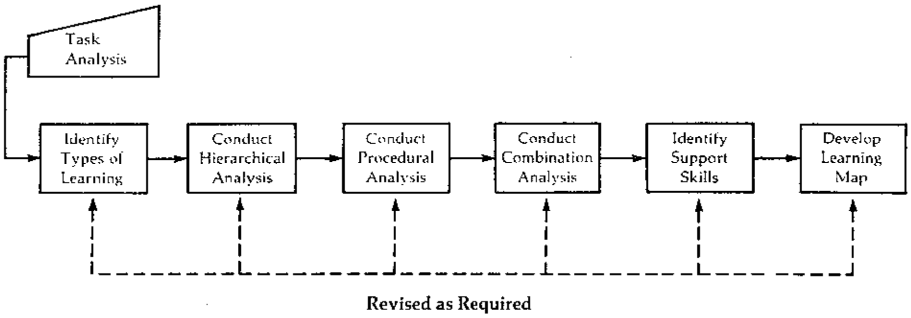


Figure 3. Conducting Instructional Analysis

learning which is often a combination of two or more of the other five types of learning and has an inherent sequence. We've labeled this hybrid *complex procedure* learning. Tasks which represent this type of learning have the following features:

- The learning of a sequence is required for successful performance.
- The major learning involved is the process itself and the inter-relationship of its components.
- The procedure is complex enough to require practice and feedback for shaping (i.e., a job aid alone would not be sufficient to assure mastery as it is in simple procedures).
- Although the components may be intellectual skills, they do not need to be analyzed as such because their subordinates are generic intellectual skills which support many terminal behaviors and have therefore already been learned by the target population.

We do *not* consider the number of steps and decisions as a relevant criterion in determining whether a procedure is simple or complex.

Note the sample analysis of a complex procedure, Figure 5, in which the subordinate intellectual skills of additional and subtraction could be assumed for most adult target populations and need not be analyzed into hierarchies.

Other examples of complex procedure learning include:

1. Conceptual Procedures or Methodologies
- Use a "formative evaluation" model.
- Apply a structured approach to analyze systems.
- Analyze performance problems according to a particular model.
- Manage a software project systematically.

2. Physical Procedures with Mental Processing
- Changing a tire
- Flying an airplane
- Raising the sails on a sailboat

One might argue that a designer can identify these skills, their components, and their sequence just as effectively by searching for them in the context of Gagne and Briggs' five domains of learning. This may be true, but we have found that it is more *efficient* to conceptualize these types of tasks as complex procedures at the beginning of the instructional analysis process, first identifying the components of the procedure to be learned and then identifying any contributing intellectual skills which may need to be learned by the target population. In this way we avoid analyzing all tasks into hierarchies of intellectual skill learning when it is likely that only a portion of the skills will need to be taught as such.

Function: Procedural Analysis

The first step is to scrutinize the task analysis flowchart to distinguish complex procedures from simple procedures. Unlike complex procedures, simple procedures are those tasks that do not require new learning for the target population but can be performed with the use of a job aid. However, if the target population is to be able to apply the underlying concepts and rules that drive the simple procedure in a variety of non-training situations that they may encounter on the job, hierarchical analysis should be conducted to identify those concepts and rules for the learning map (see next section).

Once complex procedures have been identified, the analyst must review the task analysis to assure that all components of the complex procedure have been identified. Each component is then analyzed to determine if there are any intellectual skill prerequisites which must be learned by the target population. If so, they will be further analyzed during hierarchical analysis (see next section). If not, a pure complex procedure has been identified for the learning map (graphically displayed in Figure 6), and no further analysis is required. This is a rare occurrence, however, so *combination analysis* is often required.

Types of Learning	Definitions	Designer Verbs	Example (from a course in structured systems analysis)
Intellectual Skills	Demonstrating an ability to perform a whole class of behaviors, often using symbols. "Knowing how."		
Problem-Solving		Generate	Given prose narrative describing a system, generate a data flow diagram
Rule		Demonstrate	Demonstrate that functions go in bubbles and data flows go on arrows
Concepts		Classify	Classify items as functions or data flows
Attitude	Acting on the basis of feelings, beliefs, or opinions (observed choices).	Choose	Choose to implement data flow diagrams on the job
Cognitive Strategy	Managing one's own thinking and learning processes	Originate	Originate a new design for a computer system
Verbal Information	Stating facts, names, ideas, generalizations or processes that can be memorized. "Knowing what or that."	State	State the definition of data dictionary State the benefits of using structured systems analysis
Motor Skill	Executing a physical action with smoothness and timing.	Execute	Execute a backhand in tennis*

*There are few motor skills required of the systems analyst.

Figure 4. Types of Learning (Adapted from Gagné and Briggs, 1979)

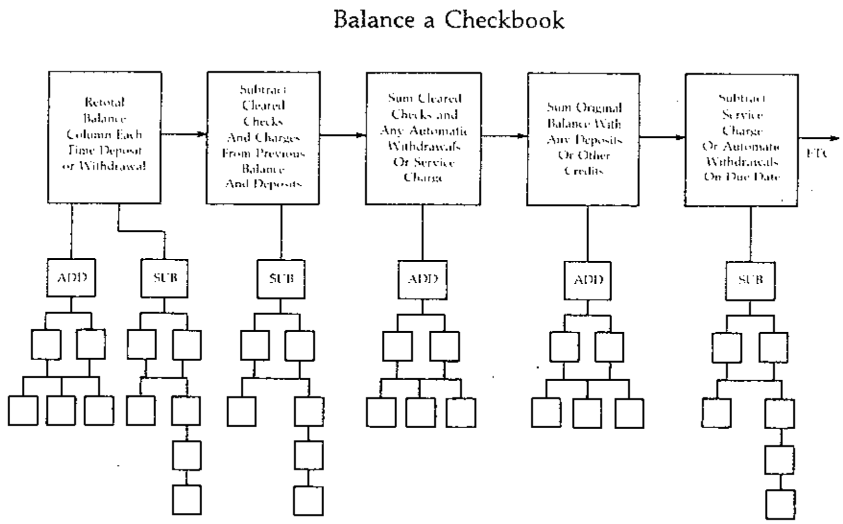


Figure 5. Example: Complex Procedure

This is a term borrowed from Dick and Carey (1978) which we use to describe the integration of complex procedures and supporting intellectual skills in the development of the learning map (graphically displayed in Figure 7).

Function: Hierarchical Analysis

Any intellectual skills identified during procedural analysis should be thoroughly analyzed to determine any subordinate skill learning required by the target population.

Any other intellectual skills identified, though not necessarily related to the complex procedures, should also be analyzed to assure that all subordinate skills are identified for learning. A top-down approach is recommended by Gagne and Briggs (1979), in which each subordinate skill identified is, in turn, analyzed to identify its subordinate(s). The portion of the learning map resulting from this phase of analysis is charted as a hierarchy. A designer may have a number of unconnected hierarchies identified at this point in the process, but they will all be integrated into the total learning map later.

Figure 8 shows the hierarchical format for graphically displaying the analysis of intellectual skills. It also shows the superordinate relationship of problem-solving to rule application to concept learning in the model from which this approach is derived (Gagne and Briggs, 1979). Theoretically, these hierarchical relationships are *necessary*— for example, a rule cannot be learned without the underlying concepts being present in memory—and only intellectual skill is actually incorporated into the new, higher level learning. This structure serves as a guide to designers in conducting hierarchical analysis of intellectual skills.

Function: Supportive Skill Analysis

Although no formal model exists to analyze relationships between information learning, attitudes, intellectual skills, and complex procedures, there is some research (Wager, 1976) to help designers identify information and attitudes that support intellectual skill and procedure learning. Figure 9 shows the prescribed facilitative relationship between intellectual skill learning, verbal information learning, and attitude learning in a real technical skills training example. Dotted lines indicate relationships between intellectual and non-intellectual skills, and arrows indicate direction of facilitative flow. Note that non-intellectual skills are presumed to facilitate, and be facilitated by, intellectual skill learning. Facilitative relationships are distinguished from prerequisite relationships in that facilitating skills may not be absolutely necessary for learning, but they are identified in situations where the designer has empirical evidence that the facilitating skills increase the chances that the desired learning outcomes will be achieved for a given target population.

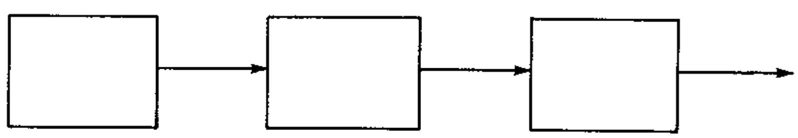


Figure 6. Procedural Analysis

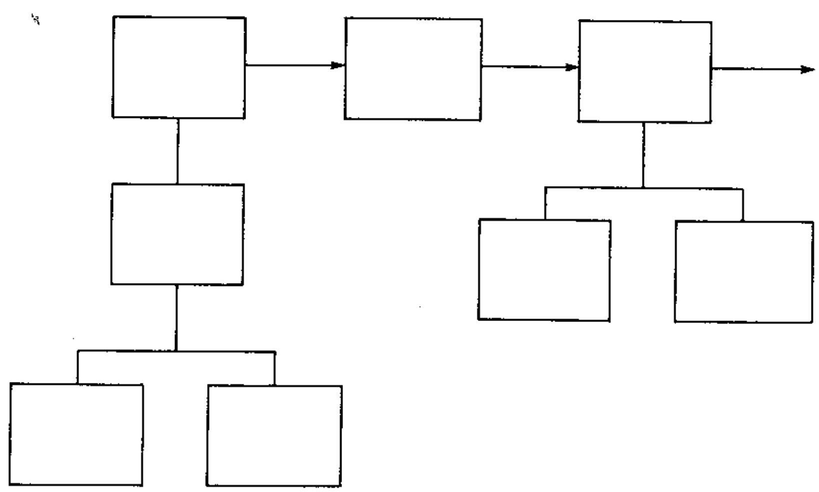


Figure 7. Combination Analysis

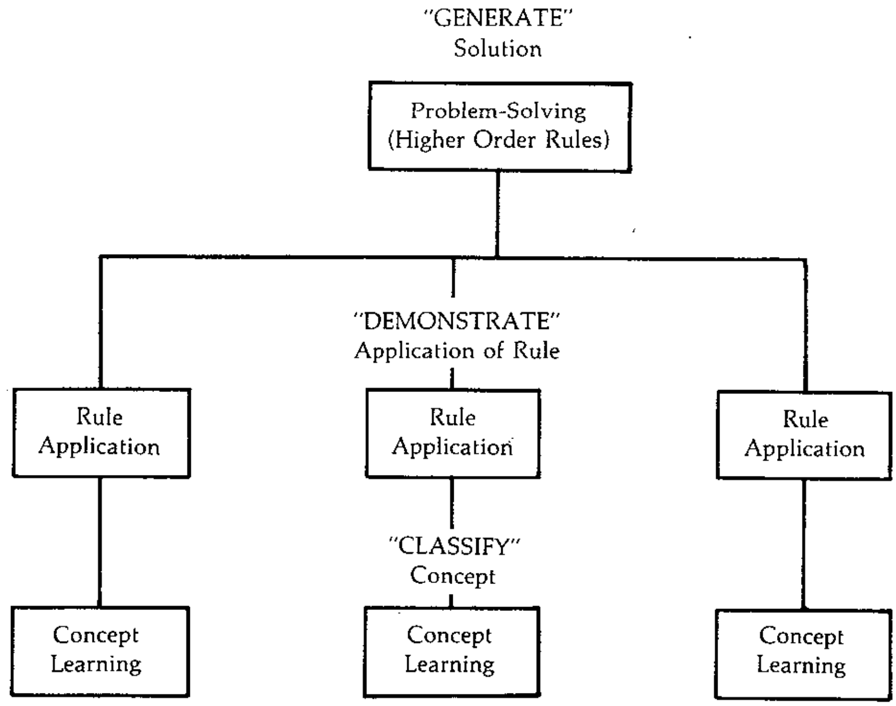
Putting it All Together in a Learning Map

This integration process first requires successive rechecking of the analysis decisions made in each function previously described. For example, after the intellectual skill hierarchies are combined with the complex procedure flows where relationships exist (combination analysis), it often becomes clear upon rechecking that there are learned components which have not been identified in either the hierarchies or the procedure flows. These components and their interrelationships must then be analyzed hierarchically, procedurally, combinationally, or as supportive skills to enhance the tentative learning map.

It is also common to find that what at first appeared to be intellectual skill learning, and was thus subjected to hierarchical analysis, was really in essence a complex procedure with a few intellectual skills supporting its major components.

Thus, in performing instructional analysis at this point, the designer is actually processing procedural, hierarchical, combination, and supportive skill analysis strategies simultaneously in order to identify all the relationships and learned components of the job—that is, combining the pieces that were previously addressed in separate functions.

Clearly, the more experience a designer has in performing instructional analysis, the more skilled (s)he becomes in seeing an overview of the learning map layout for an entire job early on in the analysis process. This overview could be described as prevalent types of learning and the major relationships between them that will form the structure of effective and efficient instruction. Figure 10 shows a portion of an actual learning map constructed at Bell Laboratories for a course on instructional systems design. The portion shown illustrates that all four subsets of instructional analysis were necessary to arrive at an accurate graphic representation of the types of learning needed, and their interrelationships, to facilitate job performance for Bell Laboratories course developers.



*Based on principles outlined by Gagné and Briggs.

Figure 8. Intellectual Skills Learning Hierarchy*

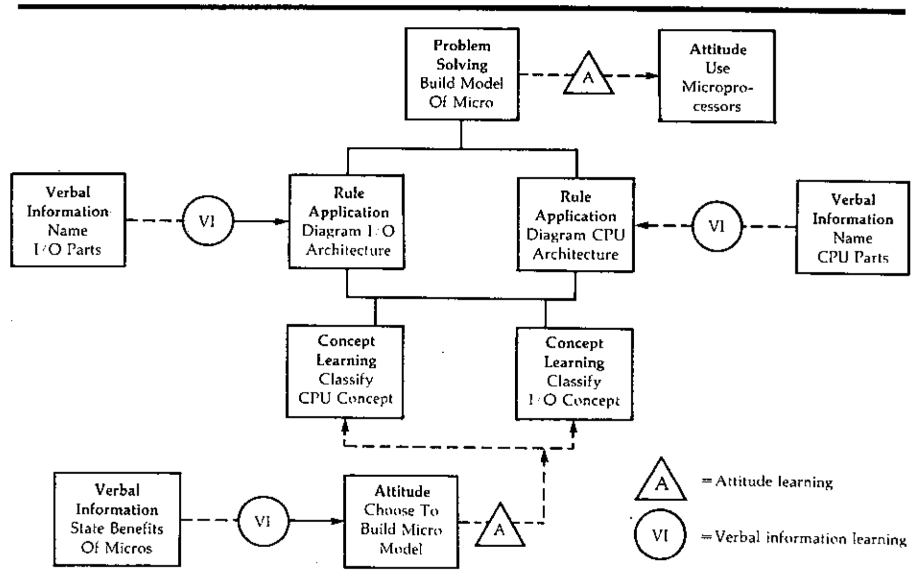


Figure 9. Sample Learning Map: Microprocessor Training

Conclusion

The instructional analysis approach described in this paper is a critical link between task analysis and the design of instructional objectives for the following reasons:

1. Moving from task analysis directly to the development of objectives is usually inappropriate, because:

- To achieve adequate performance of many of the tasks and subtasks, instruction may not be required. Unless learning requirements are analyzed, excess instruction may be produced.
- If prerequisite intellectual skills and/or supportive learning of other types are not derived, the training will be less effective.

2. Performing instructional analysis without first completing task analysis, or trying to do both simultaneously, is ineffective, because:

- The two processes are performed differently, with different goals and different outputs.
- Instruction designed without a thorough understanding of the work it is to support will have less chance of positive transfer to job performance. Task analysis provided necessary input to the instructional analysis process.

3. Determining the type(s) of learning (the cornerstone of instructional

analysis) is an essential activity throughout the instructional design process, because:

- Initially, it helps determine the most appropriate method(s) of instructional analysis.
- It provides the designer with a set of corresponding "conditions of learning" (Gagne 1977) from which to design instructional strategies.

4. Both procedural and hierarchical instructional analyses, alone and in combination, should be considered in each instructional design project, because:

- Using only hierarchies may result in forcing hierarchical relationships that aren't there, or in identification of prerequisite skills at a level too low for the target population.
- Thinking in terms of complex procedures is more appropriate when the procedural sequence itself is important to learn and when high level decision-making behavior is required rather than expert performance of each step in the procedure.

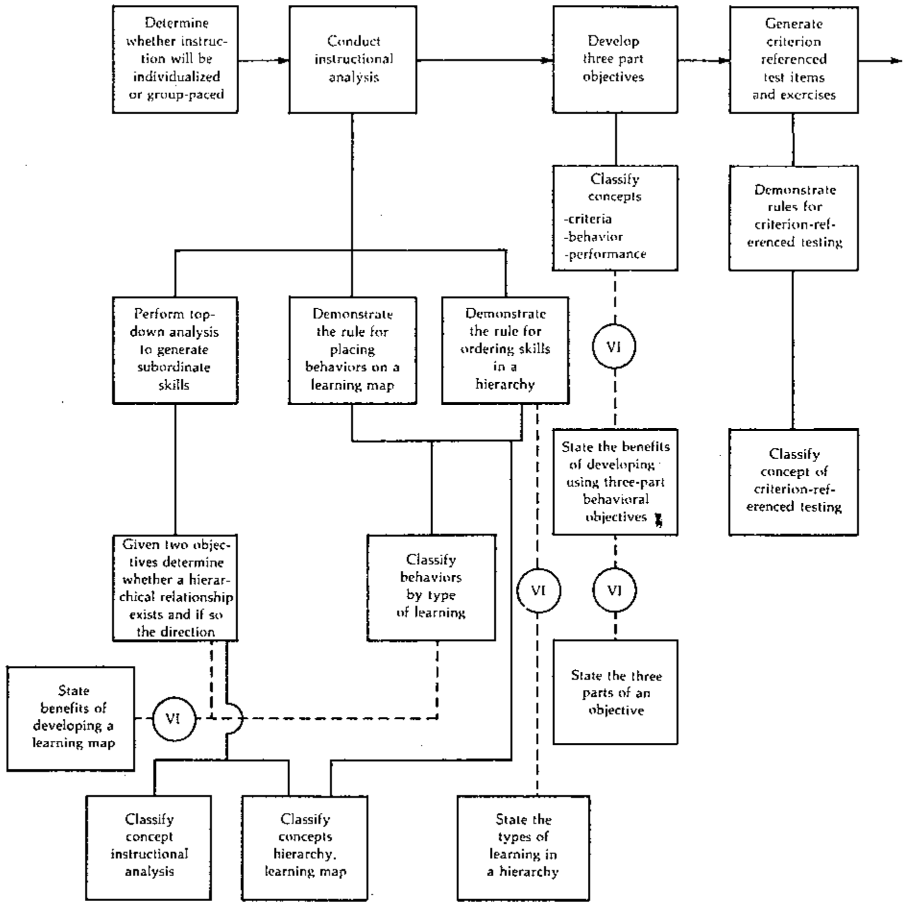


Figure 10. Sample Learning Map: Instructional Systems Design Training

References

Ackerman, A.S., Hoffman, C.K., & Medsker, K.L. (1980). *Instructional systems design-principles and techniques.* (Course Documentation) Piscataway, New Jersey: Bell Laboratories Systems Training Department.

Briggs, L.J., & Wager, W.W. (1981). *Handbook of procedures for the design of instruction* (2nd ed.). Englewood Cliffs, New Jersey: Educational Technology Publications.

Davies, I.K. (1973). *Competency based learning; Technology, management, and design.* New York; McGraw-Hill.

Dick, W., & Carey, L. (1978). *The systematic design of instruction.* Glenview, Illinois; Scott Foresman and Company.

Esseff, P.J., & Esseff, M.S. (1974). *Workbook on developing individualized instruction: Learning hierarchies and modules.* Educational Systems for the Future; Columbia, Maryland.

Gagné, R.M. (1974). Task analysis—Its relation to content analysis. *Educational Psychologist, 11,* 11-18.

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

Gagné, R.M. & Briggs, L.J. (1979). *Principles of instructional design* (2nd ed.). New York; Holt, Rinehart, and Winston.

Gibbons, A.S. (1977). *A review of content and task analysis methodology.* (Technical Report No. 2, March 1, 1977.) San Diego, California; Courseware, Inc.

Miller, R.B. (1956). *A suggested guide to position task description.* (Technical Memorandum ASPR-TM-56-6.) Lackland Air Force Base, Texas; Air Force Personnel and Training Research Center.

Wager, W.W. (1976). *Instructional curriculum mapping.* Paper presented at the Annual Spring conference of the American Educational Research Association, San Francisco, April.