ference on Education, 43rd session, Geneva 1992. Ministry of Education and Culture, Dar es Salaam.

Further Reading

Ministry of Education 1986 *National Report of the United Republic of Tanzania.* International Conference on Education, 40th Session Geneva 1986, Ministry of Education, Dar es Salaam

Ministry of Education 1989 *Education for All: Meeting Basic Learning Needs, to the Year 2000, Tanzania National Document.* Ministry of Education, Dar es Salaam

Ministry of Education 1990 *National Report of the United Republic of Tanzania.* International Conference on Education, 42nd session, Geneva 1990. Ministry of Education, Dar es Salaam

Ministry of Education and Culture 1992/93 Budget speech. Ministry of Education and Culture, Dar es Salaam

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Task Analysis

Task analysis is a process used to develop understanding of what is involved in performing and/or learning to perform a task: either a skill, a procedure, or an area of content. In most cases its purpose is to help determine appropriate methods for improving performance of that task, primarily by helping an instructional designer to decide what to teach (content) and how best to teach it (methods). The present entry defines task analysis and describes various purposes it can serve. Major techniques, key questions, and important research issues are discussed.

1. What is Task Analysis?

In a general sense, task analysis determines what is involved in meeting a given goal or need. It follows the process of needs assessment, through which the designer determines where learning or some other form of performance enhancement is required. Thus, task analysis is a process used to develop understanding of what is involved in performing and/or learning to perform a task. This includes the skills and knowledge that are relied upon, the thought processes engaged in, and/or the actions taken in performing the task. Task analysis can also provide information on such factors as the environment where performance takes place, the criticality of the task, typical errors, and the consequences of good or poor performance. In a general sense, the task analyst asks what has to be done by whom, how, when, where, and with what level of skill. Task analysis results in a representation of the task—for example, a list of visual map of task elements and their relationships—that is useful in facilitating performance and/or designing instruction.

The term "task analysis" is often used rather broadly to include analysis of subject matter or content. Related processes that are sometimes considered types of task analysis include job analysis, skills analysis, goal analysis, and instructional analysis.

2. Purposes of Task Analysis

Jonassen et al. (1989) have identified five functions for task analysis, the last three of which are instructional purposes: inventorying tasks, describing tasks, selecting tasks for instruction, sequencing tasks (and subtasks) in instruction, and analyzing task and content level (for selecting instructional strategies). Task analysis information can be useful in such areas as worker selection, training selection, performance appraisal, job design, instructional design, and others. For worker selection, workers can be selected for a job based on their preparation in terms of the skills and knowledge identified by the task analysis. For training selection, a worker might be required to complete only those aspects of a training program that match task elements where his or her skills are lacking. For performance appraisal, results of the task analysis can be used as criteria for evaluating performance, making it easier to identify areas of deficiency. For job design, it is frequently possible to find ways to improve the person–job system (e.g., the task environment or the way the task is performed). For example, the task representation can serve as a job aid, placing knowledge in the world rather than in performers' heads. As this implies, task analysis often eliminates the need for further work; learning simply to use the aid rather than to remember task steps may be all that is required. For instructional design, designers of courses and curricula use information from a task analysis primarily to identify what individuals need to learn, how instruction should be sequenced, and what instructional strategies and tactics should be used.

Task analysis offers the potential benefit of helping a designer to avoid (or eliminate) content that is irrelevant to achieving the goal. This can decrease costs by reducing training time and reducing the need for learning on the job. On the other hand, it is possible that omitted content could have had unanticipated benefits, say in helping the learner understand other aspects of a job. Therefore, while benefits can be great, task analysis has potential to limit the designer's thinking to those aspects of performance which can be observed and explicitly stated. It is prudent to view task analysis as an aid rather than a prescription in designing, and to analyze problems logically and pose solutions creatively. Further areas where task analysis information is useful include troubleshooting, resource allocation, manual development, and test construction. Task analysis is also a powerful tool used by engineers to increase reliability and reduce error. This entry will focus on task analysis for purposes of instructional design.

3. How Is Task Analysis Carried Out?

Techniques for carrying out task analysis can be grouped into at least five major categories: those which identify subordinate learning skills; those which identify procedural steps; those which identify causal models underlying complex cognitive tasks; those which identify content elements; and those which help the designer to select appropriate instructional strategies. Each of the first four techniques seeks to determine the elements of the task or content area, the relationships among those elements, and the organizing principle that ties all elements together. The fifth technique seeks to determine the kind of learning involved so that appropriate instructional strategies and tactics can be selected. Selection of a particular technique depends primarily on the type of goal involved or the purpose of the analysis, and such classification is typically the first step in conducting the analysis.

Task analysis of subordinate skills assumes that learning a complex skill involves mastery of a number of more simple subskills. If those subskills can be identified and sequenced according to learning prerequisite relations, then learning should be more effective and efficient. The most widely used technique is the learning hierarchy (Gagné 1968), a representation of the task as a visual map of prerequisite skills. Learning entry-level skills at the base of the hierarchy is expected to lead, or "positively transfer," to learning intermediate skills (enabling objectives) in the middle, and to learning the goal (terminal objective) at the top. This technique is especially useful in criterion testing, selection, and placement, and in sequencing instruction. It is often selected when the goal involves performance of an intellectual skill. A disadvantage is that the hierarchy does not show procedural relationships.

Procedural task analysis assumes that tasks are performed as sequences of specific cognitive processes and actions. Hence, task acquisition and performance can be facilitated by identifying steps and representing them in algorithmic form, for example, in a flowchart or decision table. There are two major kinds of procedural task analysis: that which merely identifies the order of steps in a procedure (see e.g., Merrill 1976), and that which also arranges different versions of the task in order of complexity, such as Merrill's (1976) path analysis technique or the Elaboration Theory's simplifying conditions method for procedural content (Reigeluth 1992). Procedural task analysis is often selected when the goal is a physical action or psychomotor task, or an intellectual skill with a fairly limited number of ways it can be performed by experts. It is not appropriate for complex cognitive tasks that vary greatly from one performance to another.

Task analysis of complex cognitive tasks assumes that such tasks are not performed by experts as a sequence of steps; rather experts have an underlying body of knowledge—a set of principles or causal models—that they use to generate an appropriate performance for each particular situation. Therefore, such tasks require a type of task analysis that identifies the underlying principles or causal models that experts use to perform them. There are also two major kinds of complex-cognitive-task analysis: that which merely identifies the underlying principles, and that which also arranges different versions of the task in order of complexity (see e.g., the Elaboration Theory's simplifying conditions method for causal models—Reigeluth 1992). This technique is selected only when the goal is a complex cognitive task.

Task analysis of content elements assumes that some important knowledge is not tied to any one specific task (or goal), such as an understanding of some basic principles of economics or biology. This technique results in some sort of visual map of content, such as an outline, a content taxonomy, or a chart. A content map can provide a powerful tool for a designer to sequence instruction and for a learner to grasp relationships, but it does not identify what the learner should be able to do as a result of learning. That is, the skills or learning outcomes are not made explicit by the map. In carrying out an analysis of content (and in using most other techniques), analysts often employ a card sort method, writing elements on cards, sorting, selecting, and organizing the cards, and then linking them together.

Task analysis of kinds of learning differs from the above kinds of task analysis in that it does not break down a task into parts; rather it classifies the parts in order to select appropriate instructional tactics. It is based on the assumption that different kinds of learning are best taught with different kinds of instructional tactics. This intact classification of task elements is based on a taxonomy, such as Bloom's or Gagné's (1986) or Merrill's (1983). After a task element has been classified as to the type of learning involved or desired, a set of tactics is assigned for teaching that kind of learning for that element. The most common categories include cognitive, affective, and psychomotor learning, and, within the cognitive domain, memorizing information, understanding relationships, applying skills, and using generic (domain independent) skills (Leshin et al. 1992). The strategy or tactics are then adapted and supplemented based on the learning situation (content, learners, and learning environment).

Often, the learning goal leads to selection of a certain task analysis technique. For example, a psychomotor task such as operating a machine can be expressed as an algorithm fairly easily. Just as often, however, the nature of the goal is not so easily classified, and several different techniques are candidates. Also, the analyst can select one technique, but one technique provides a single perspective. It is often wise to use more than one technique or to combine several. For example, algorithmic elements could be identified for a subordinate skill, or subordinate skills could be identified for a procedural step. Content elements might be attached to either. Reigeluth and Merrill's (1984) extended task analysis procedure represents such a combination.

The techniques described above are representative. Other techniques include path, critical incident, fault tree, pattern noting, and matrix analysis. See Jonassen et al. (1989), Zemke and Kramlinger (1982), and Carlisle (1986) for descriptions of these and many other techniques, and for sample task representations.

The selection of a task analysis technique or techniques will be influenced greatly by the purpose of the analysis. A variety of purposes was listed in the previous section of this entry, but even within the instructional design focus selected here, purpose can include selecting and sequencing the course content (which is the purpose of most of the above-described techniques) or selecting instructional strategies and tactics.

Regardless of the purpose within the instructional design focus, the role of task analysis is to provide information needed for good instructional design decisions. Thus, selection of methods of task analysis should be driven by the information needs at each point in the design process. Task analysis should not be viewed as an activity totally independent from design. In many cases, the instructional theories that a designer selects will specify what those information needs are, because the theories prescribe methods for different situations, particularly for different types of tasks. In effect, theories of instruction require the analyst to seek certain types of information about the tasks in order to select appropriate content, sequences, strategies, and tactics. Therefore, theories of instruction can be seen as having corresponding task analysis methods (although those methods can also be used independently of a given instructional theory). In cases where instructional theory is driving the design, the goal of task analysis becomes not just identification of elements and relationships, but doing so in a manner which supports designing instruction according to the theory.

After a task analysis technique (or combination of techniques) has been chosen, information about the task must be collected. Sources of information for task analysis include various levels of job performers (e.g., novices and experts), supervisors, instructors, content experts, and learners. Also useful are reference guides, training materials, manuals, logs, and other documents, and potentially anything that exists in the physical environment. Data are gathered using unobtrusive participant observation of the job, individual interviews, structured or unstructured group interviews, surveys, and study of documents (Jonassen et al. 1989).

Task analysis tools have been developed that reveal some information on processes that previously remained implicit in performance. For example, cognitive task analysis (Roth and Woods 1989) requires performers to think aloud as they perform tasks. Analysis of the resulting think-aloud protocols gives at least partial evidence of the thought processes performers engage in during performance of the task. These data are believed superior to retrospective reports. That is, the performer describing task performance after the fact often constructs a hypothetical argument of what he or she may have done, as opposed to what really occurred. Of course, skill components that cannot be verbalized, for example, procedures that are performed "automatically" and are no longer consciously controlled, will not appear in a protocol.

4. *Key Questions*

Perhaps the most difficult questions to answer in conducting a task analysis are where to start and where to stop. When task analysis is employed for creating instruction, the first question, where to start, is difficult but manageable. The analysis should begin with the goal, the broadest statement of what learning is sought, and move to progressively greater levels of detail. This goal is never completely clear, and is much less clear at the outset, but it can at least tentatively be stated and agreed upon.

The second question, where to stop, is more challenging. What to include and what to exclude and how much detail to add or cut are rarely easy decisions. Generally, the learners' abilities and prior knowledge are the major basis for making these decisions. That is, the instruction should start at the learners' current level of skill and knowledge. Ultimately, it is a question of risk management, which must assess the tolerance for error and the consequences of including too much or too little content.

5. *Issues and Directions*

It is important to recognize that the types of task elements that are identified—for example, subskills, steps in a procedure, underlying principles or causal models, or content elements—and the processes used in breaking the task down, are based on theories of human performance, knowledge, or learning. As those theories advance, new methods of task analysis are developed. Furthermore, different methods of task analysis are compatible with, and useful for, different kinds of learning and different approaches to learning. Thus, analysts break a task down in a particular way because they believe it will be most useful for their situation and philosophy of learning and instruction.

For example, techniques based on a behavioral tradition identify types of behaviors or kinds of learning outcomes (Gagné 1986). In contrast, techniques based on cognitive psychology attempt to describe mental processes that underlie those outcomes. In the case of procedural tasks, the two traditions may often identify the same elements, but in the case of complex cognitive tasks, the differences are great.

Techniques such as cognitive task analysis appear to have much potential. Task analysts or "knowledge engineers" seek to describe the knowledge of experts and to express that knowledge in computer software programs known as expert systems. Significant progress has been made in this area, and expert systems have been developed which do a fair job of solving some problems as experts do. However, a number of constraints on development of expert systems remain, including a primitive understanding of cognitive processes underlying performance, the domain-specificity of expertise, and—as a major consequence of these two factors—the great amount of time needed to develop a single system.

Efforts to understand performance in terms of the mental processes involved include Sternberg's (1983) componential analysis and Rasmussen's SRK or skills, rules, and knowledge (see Goodstein et al. 1988). However, intellectual performance may also be influenced by such things as beliefs and social processes. Furthermore, although general characteristics of experts have been described, there is the clear notion that much of the knowledge and skill of an expert in one domain does not transfer to another. As a result, task analysis or "knowledge acquisition" processes must be repeated for each and every domain. It is also important to note that these techniques, while appropriate to building systems that imitate the behavior of an expert, are not necessarily appropriate as pedagogical tools. The gap between an expert and a novice may be made clear, but how best to help a novice become an expert remains a matter of instructional design.

Since the mid-1980s, increasing credence has been given to a "constructivist" epistemology which views learning as the active development of meaning on the basis of experience. Learning is seen as a constructive act, and the designer should provide for rich experiences by situating activities in authentic contexts and provide for exploration and sharing of multiple perspectives. The implication of this view for task analysis is that, for some learning situations, the learning environment should not be limited to specific task elements and relationships. The analyst may still seek a core of information to make available to all learners, but should avoid setting boundaries on what information is deemed relevant and included for such learning situations. The goals and methods of task analysis from this perspective, and how results can be implemented in instructional systems, are not entirely clear, but efforts are under way in this area.

A second issue concerns when task analysis should be conducted. Task analysis can be seen as a process engaged in after needs assessment and before design. But the costs of performing a task analysis are often high and, therefore, resources are infrequently committed before a clear goal or performance gap is identified. Nevertheless, an iterative process may yield better results. That is, task analysis can inform needs assessment, and design can inform both needs assessment and task analysis. A cyclical approach with feedback and feedforward is implied. A rapid prototyping methodology such as that offered by the Elaboration Theory's simplifying conditions method (Reigeluth 1992) may offer a key to managing such a cyclical process, particularly with a large project and a large design team.

A final issue relates to the potential for computers to assist the analyst, for example, in reducing the amount of time and effort needed to develop an expert system. An example of a computer program designed to help the task analyst is SNOWMAN, or System for Knowledge Management. The potential for computers to assist designers in these and other processes have been explored. Gayeski (1991) raises some questions regarding the nature of such programs, that is, where and for what types of problems such systems, at least as conceived at that time, are appropriate and useful.

See also: Problem-solving and Learning: Computer Modeling; Constructivism and Learning; Instructional Design Theories; Instructional Psychology (as a Contributing Field to Instructional Design); Job Analysis in Corporate Education; Learning Processes and Learning Outcomes; Models of Learning

References

Carlisle K E 1986 *Analyzing Jobs and Tasks*. Educational Technology Publications, Englewood Cliffs, New Jersey

Gagné R M 1968 Learning hierarchies. *Educ. Psychol.* 6(1): 3–6

Gagné R M 1986 *The Conditions of Learning*, 4th edn. Holt, Rinehart, and Winston, New York

Gayeski D M 1991 Software tools for empowering instructional developers. *Performance Improvement Quarterly* 4(4): 21–36

Goodstein L P, Andersen H B, Olsen S E (eds.) 1988 *Tasks, Errors, and Mental Models*. Taylor and Francis, London

Jonassen D H, Hannum W H, Tessmer M 1989 *Handbook of Task Analysis Procedures*. Praeger, New York

Leshin C, Pollock J, Reigeluth C M 1992 *Instructional Design Strategies and Tactics*. Educational Technology Publications, Englewood Cliffs, New Jersey

Merrill M D 1983 Component display theory. In: Reigeluth C M (ed.) 1983 *Instructional Design Theories and Models: An Overview of their Current Status*. Erlbaum, Hillsdale, New Jersey

Merrill P F 1976 Task analysis: An information-processing approach. *NSPI Journal* 15(2): 7–11

Reigeluth C M 1992 Elaborating the elaboration theory. *Educ. Tech. Res. Dev.* 40(3): 80–86

Reigeluth C M, Merrill M D 1984 *The Extended Task*

Analysis Procedure: User's Manual. University Press of America, Lanham, Maryland
Roth E M, Woods D D 1989 Cognitive task analysis: An approach to knowledge acquisition for intelligent system design. In: Guida G, Tasso C (eds.) 1989 *Topics in Expert System Design: Methodologies and Tools*. North Holland, Amsterdam
Sternberg R J 1983 Components of human intelligence. *Cog*. 15 (1–3): 1–48
Zemke R, Kramlinger T 1982 *Figuring Things Out: A Trainer's Guide to Needs and Task Analysis*. Addison-Wesley, Reading, Massachusetts

Further Reading

Duffy T M, Lowyck J, Jonassen D H (eds.) 1993 *Designing Environments for Constructive Learning*. Springer-Verlag, Berlin

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Taxonomies of Skill Development

Skill development programs are operated by many different public agencies in many different settings. Training is also provided in the workplace as an ancillary activity to production (on-the-job training) in both public and private sectors. Lastly, training is offered by proprietary firms that specialize in skill development. In some countries, a piece-by-piece approach to building a system of skill development has created serious problems with respect to coordination and coverage. This entry proposes a taxonomy of skill development programs to guide appropriate placement and sponsorship of particular training programs in an integrated system of skill development. The taxonomy should also be useful in clarifying the appropriate distribution of financial responsibilities to assure adequate and stable funding for training programs. The overall objective is to assist in designing systems of skill development that are productive, efficient, and equitable.

1. Some Characteristics of Preferred Training Systems

A preferred training system will be accountable for maintaining standards of skill development in industrial fields that allow sustained economic growth to take place. Neither qualitative deficiencies nor quantitative shortages of skills should be bottlenecks in the process of economic development. A related objective is to avoid surpluses of trained workers in given occupations. A preferred training system will also ensure a rising standard of competence among workers in the social sectors (health, education, community development). In both the industrial and the social sectors, desired worker characteristics include problem-identifying and problem-solving abilities, the capacity to communicate in oral and written forms, and the flexibility to master new tasks as work processes change. Not all actual or potential training agencies have equal capacity for high quality skill development. For example, if the objective is to produce top-flight electronics technicians, a large firm with a strong commitment to research and development will likely offer a better kind of training than a village workshop. Not all agencies have the same degree of flexibility to meet the shifting demands of the labor market. Public agencies with more or less fixed budgets and tenured trainers may have difficulty in responding quickly to sharp increases or decreases in demand for particular types of workers.

A preferred training system will be efficient. The trainers will be proficient in the skills they are teaching and they will be well-motivated. The mix of theoretical and practical learning will be appropriate to the tasks the graduates will perform. The equipment available in training sites will be technologically up-to-date, in good repair, and heavily utilized. The trainees will have their motivation to learn enhanced by seeing a clear connection between their acquiring a high standard of proficiency and career advancement. The opportunity costs of trainees will be at an appropriate minimum. Rates of student wastage will be low and long interruptions in training will be avoided. A creditable system of student assessment and program evaluation will be in place. In a preferred training system, all agencies will have a stable and adequate level of funding. Stable and adequate funding appears to be best achieved when the costs of training are distributed to the direct beneficiaries of skill development. Direct beneficiaries are ordinarily of two main classes: trainees and employers. In particular cases, either class of beneficiary, or both together, may contribute to cost recovery.

Lastly, a preferred training system will be equitable, in the sense that access to give training opportunities is truly meritocratic, not determined by family status or caste. Taking account of the fact that potential trainees are likely to be dispersed geographically, to have different needs for support systems, and to display different tastes for ways in which training is presented, a certain amount of redundancy in the training system is probably helpful in attaining the equity objective. No single agency should necessarily be solely responsible for developing a particular set of skills. Redundancy, however, can be nonfunctional and interfere with attainment of the efficiency objective.

2. Forms of Skill Development

The usefulness of a taxonomy of skill development is underscored by the great variety of multiple location, multiple delivery programs for training that are in place in the early 1990s. A prime example of such diversity is the United States. In the public sector, Wirt et al. (1989) have reported that skills training is provided in comprehensive secondary schools,