SELECTION AND UTILIZATION OF PROBLEM INFORMATION BY INSTRUCTIONAL DESIGNERS

by

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(ABSTRACT)

Based on the notion that instructional design is a goal-directed problem-solving activity, this study seeks to describe and compare the ways that instructional designers organize and utilize problem information in making design decisions. Research in areas such as architectural, computer software and engineering design suggests that the design process involves identification and selection of a variety of elements from a large number of possible configurations. Designers tend to decompose design problems into smaller sub-problems which can be solved separately. Little is known about how problem information is used by instructional designers, but it is likely that the instructional design process is similar to design in other domains.

Participants who had a minimum of five years of instructional design experience in a variety of settings accessed information contained on individual note cards in order to develop a tentative solution to a problem involving training for librarians. The data provided by videotapes of the think-aloud sessions was analyzed to determine which information was selected, the sequence in which the information was accessed, and the strategies used to acquire the information and use it in designing a solution. Results

indicated that certain categories of information, particularly information about the learner, skills to be trained, time for training and available resources, were accessed more than others. Designers also tended to access the information in similar sequences.

The descriptions provided by this research may help to achieve a better understanding of the instructional design process. Once we know how designers organize the process, it will be possible to track the development of instructional design expertise.

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What is it that designers do when they design? Depending on the situation, design (in the general sense), has been described as decision making, simulation, a creative activity, a scientific process or "a very complicated act of faith" (Freeman, 1983, p. 3). Recently, engineers, architects, commercial designers and computer scientists have become interested in the question of how humans select certain elements from a large number of possibilities, and combine these elements to develop a functional and aesthetically pleasing solution to a problem (Zaff, 1987). As of yet, there is no definitive answer to the question of how people design. What is suspected, however, is that design combines both rational and intuitive thought processes which are derived from the knowledge and creativity of the designer (Nadin & Novak, 1987).

Certainly, how a designer proceeds is related to what is being designed. Design problems can be roughly characterized as belonging to one of three classes (Chandrasekaran, 1987). Class One design problems, which are rarely found in most design situations, require innovative behavior where neither the knowledge sources nor the problem-solving strategies are known in advance. Such activity might be more properly termed creating or inventing, and results in a completely new product. Class Two design problems are closer to routine, but may require some innovation because of the introduction of new requirements for a product that has already been designed. In such cases, the knowledge sources are known in advance, but the problem-solving strategies are not. Class Three design is the most common type of design, and routinely proceeds "by selecting among previously known sets of alternatives" (Chandrasekaran, 1987; p. 122).

The designer knows at each stage what options are available and in which order to select them.

This is not meant to imply that even Class Three design problems are simple, however. The overall task is still too complex to be done by merely looking for solutions in a design database because there are too many possible combinations of requirements (Chandrasekaran, 1987). This characteristic has led many to distinguish design problems from other, more conventional problems because of an ill-defined or "wicked" nature (Rittel, 1986). In other words, if an exact method for solving the problem exists, implying that there is one "correct" solution, then there is no design involved (Neuckermans, 1975).

Design goals are often poorly specified, and can involve the performance goals for the object, constraints on the development process (cost, etc.) or constraints on the design process (time for completion, etc.). Part of the designer's task is to formulate more specific goals based on the constraints of the problem. For example, given the same set of data and the goal to derive an equation that describes the mathematical function of the data, different people might use different procedures to derive an equation. In such a case, there is a clear one-to-one relationship between the problem and the solution, and it will be the same solution each time regardless of the procedure employed. This is problem solving, but it is not design. On the other hand, if the goal is stated less precisely, such as "find a way to use these numbers", another person could decide to take the same set of data and convert it into musical sounds through a process of selecting certain numbers and eliminating others, and then programming a computer to transform the data into sound. In this case, the person is designing a solution by viewing the problem outside of the normal conventions. Design, then, is looking at a problem which includes "some ill-definedness in the goals, initial conditions or allowable transformations" (Thomas & Carroll, 1979; p. 5).

In a similar sense, those working in the instructional design field identify a wide

range of possible strategies and materials which might be used to solve an instructional problem. The instructional designer then identifies criteria for selecting and eliminating various elements, and finally makes decisions based on these criteria (Kerr, 1983). The organization of this process of generating, selecting and evaluating alternatives is often provided by a conceptual framework in the form of a design model. Although there are numerous design models available (see Andrews & Goodson, 1980), most models tend to share general features, including the use of flow diagrams or suggested steps to be taken in the process. Most instructional design models also provide for frequent evaluation and revision of the product while it is under development. And finally, these models insist that instructional goals be well specified, and that strategies and materials be developed to meet these goals (Kerr, 1983).

The problem is that these models do not go far enough. Design models provide a way for a designer to communicate to others the general heuristics for the process, thereby establishing the domain of the instructional design process, but few specifics are provided by these models to guide the designer in operating within the domain (Kerr, 1983). The process is made to appear overly mechanistic, even linear, as if filling out the right tables and identifying the right constraints will cause the solution to pop out with little effort. This problem of oversimplification of a complex process is common in many fields. As Ullmer (1988) has noted, the "tendency to plan and act as if complex problems were much simpler than they actually are" has been a major force in American planning and management strategies (Ullmer, 1988; p. 14).

Another problem with many models of instructional design is the basis in the largely behaviorally oriented systems theory (Kerr, 1983). The focus of much work in instructional design has been to utilize systems theory to develop products which are based on an analysis of the input, output and processes identified in an instructional system. Instructional design is often likened to the production of "blueprints" which describe

methods for changing student knowledge and skills, indicating a product orientation. As a discipline, instructional design is said to produce knowledge about which "blueprint" is optimal for a given situation (Reigeluth, 1983a). Here the emphasis is on the product of instructional design, and not the process. There are many theories which prescribe a particular "blueprint" for the development of optimal instruction for various situations (See Reigeluth, 1983b), but fewer ideas have been proposed about how the process is best undertaken by individual designers.

The preceding comments are not meant as an indictment of systems theory. Instead, the suggestion is that a reconceptualization of systematic instructional design needs to be developed. It is necessary to provide a better description of how the designer controls the process of making decisions about the solution of an instructional problem. A description based on instructional design as problem solving may provide a better characterization. The systems approach provides a means for solving problems in a holistic fashion by breaking the problem into a series of subproblems that relate in various ways to the overall problem. With this approach, it is necessary to consider the relationship of subproblems to each other (and to the whole) in order to efficiently coordinate resources and organize the process (Churchman, 1968). But ultimately, design involves personal choices based on a sense of what is right (Kerr, 1983), and systematic methodologies can only provide a framework for such decisions.

To effectively use a systematic design model, the instructional designer must be familiar with sophisticated systems analysis techniques. But the designer must also develop an appropriate "mode of thinking" in order to use a systematic methodology for making the personal choices and decisions that are necessary in designing instruction. This mode of thought requires consideration of the problem as a whole, understanding of systematic problem-solving procedures and attention to details which may constrain the process (Sherman, 1978). Also, to make appropriate decisions based on personal choice

and experience, the designer must "internalize" design processes in order to "artistically and creatively use a scientific process" (Martin, 1984; p. 18).

In other words, the instructional designer must become an effective information processor, storing the details of the design process in efficient cognitive structures, thereby enabling the designer to focus on the details of the problem, and letting the process unfold without significant conscious attention. The designer must also develop an internal "library" of plans which can be used in recognizable situations where prior experience has produced a sequence of design decisions that usually work for particular situations. Because the instructional design process involves the use of cognitive strategies for recognizing problem features which are similar to previous problems, this "internalization" likely develops through experience. The ability to use a systematic design methodology is related to an individual's knowledge base, decision-making skills, procedural sophistication and experience in using a systematic design model (Banathy, 1987). Each individual designer follows a different approach or "mode of thinking" for a design situation, but it is likely that these approaches are similar, especially for experienced designers (See McCombs, 1986; Nelson, Magliaro, & Sherman, 1988).

When examining the design literature of areas such as architecture, computer software, engineering and education, it seems that these fields have little in common because of the many discrepancies in terminology, methodology, definition and purpose. But when viewed from the broader perspective of cognitive psychology these discrepancies become minor, and the picture of design which emerges reveals many similarities across domains. Any description of the instructional design process may benefit from a closer examination of the research in these other domains. In general, the idea that design is a type of problem solving activity involving ill-structured problems is based on the description of problem solving proposed by Newell and Simon (1972). Further support is provided by research in planning, decision making and design in other domains.

This literature will be reviewed in the following pages, with the understanding that the psychological study of design from the perspective of cognitive psychology can provide information about human behavior within the context of a complex, real-world situation. By studying the design process, the findings of laboratory research can be augmented and clarified within a larger setting, providing more information about the characteristics of human behavior in such situations, as well as the processes and information that are critical for successful design activity.

The research study reported here examines the instructional design process in terms of the information that is utilized during the initial stage of understanding a design problem. This information is used to establish the parameters of the problem at the outset of the process, and may also invoke solution possibilities based on the prior experience of the individual designer. By determining the critical information used by instructional designers, and the processes by which decisions are made based on this information, a better understanding of the instructional design process can be achieved. Once we know how experienced instructional designers approach the design process, it may be possible to better track the development of this expertise. But before such goals can be reached, the process of instructional design must be more clearly defined and explained. It is hoped that this research can provide at least a step in the right direction.

Theoretical Perspectives

One way to understand what an instructional designer does and how instructional design activities are undertaken is to anchor such an investigation in the theories of cognitive psychology, particularly information-processing and problem-solving research. Recently, new theoretical approaches in cognitive psychology have stimulated renewed investigations of the structures and processes of the mind, and how these facets influence learning and problem solving. The results of this research can also be used to describe how design can be characterized as a problem-solving activity, how the limitations of the information-processing system affect design activity and how prior experience impacts on the process.

The Human Information Processing System

Although numerous models of the mind have been proposed, the view which has received a great deal of acceptance is the information processing model based on the analogy of the computer. Although the human brain certainly does not function like a computer, the metaphor does help to explain the organization and processing of information that occurs. Atkinson and Schiffrin (1968) proposed a three-stage model of human information processing which has been widely accepted by many cognitive psychologists. This model assumes that the brain contains three major structures which work together to process information from the environment: the sensory registers, short-term memory and long-term memory.

Figure 1, based on Atkinson and Schiffrin's (1968) modal theory of memory, represents these structures as well as illustrating the "bottleneck" which occurs within short-term memory because of limited capacity and processing capability. Information from the environment is held briefly by the sensory registers in essentially the same form in which it is received from the sensory receptors. Attentional and perceptual processes organize and derive meaning from this information. Short-term memory is the structural

analog to the computer's central processing unit. Information arriving from the environment through the sensory registers, or information transferred from long-term memory, is processed within short-term memory. Long-term memory serves as a storage medium with nearly unlimited capacity, and is accessed by short-term memory for both input and output processes. Output from the system is produced at the effectors, and includes speech and movement.

Much of what we do, from fixing a sandwich for lunch to solving a complex mathematical problem, requires memory for things that happened in the past. Long-term memory is where this knowledge is stored, allowing the ability to interpret current situations in terms of past experience or to recall general knowledge to apply to new situations. Memory does not simply involve recall, however. There is also the need for performance, which relies heavily on long-term memory (Norman, 1982). Many cognitive psychologists make distinctions between the types of knowledge which can be represented in long-term memory, including declarative, which is knowledge about things, and procedural, which is knowledge of how to perform various skills (Shuell, 1986).

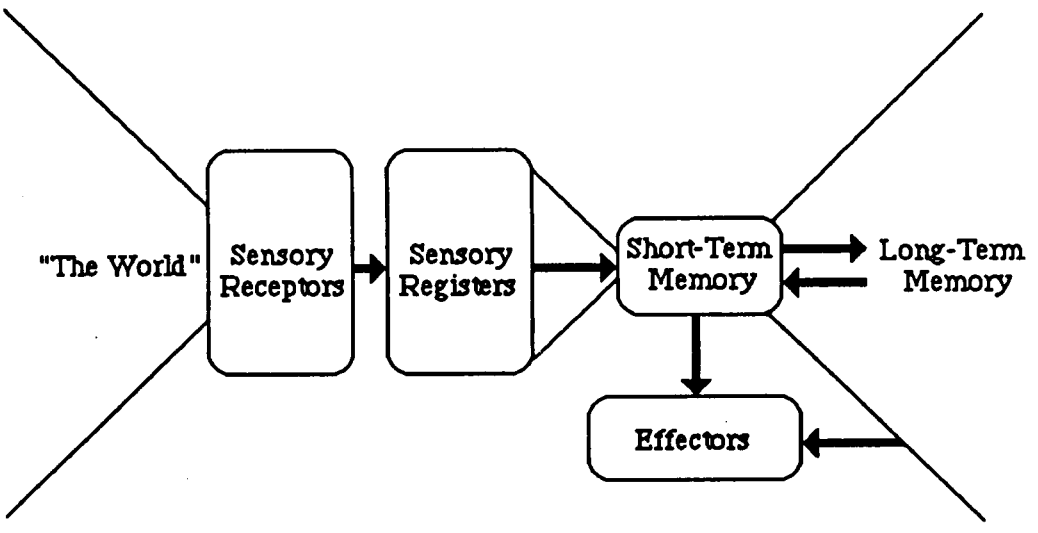

Figure 1. The Human Information Processing System.

Declarative knowledge is usually thought to be represented in long-term memory as a set of interconnected concepts or propositions which are organized in networks (Anderson, 1976; Anderson & Bower, 1973; Norman & Rumelhart, 1975). Propositions are more complex than concepts in that they represent basic ideas such as "A canary is a bird" in single units, rather than in conceptual networks or lists of features. A proposition is formed by combining concepts such as "canary" and "bird" with a subject-predicate association like "is a". Propositions can also consist of relation-argument associations, such as "lives-cage". The second type of proposition can be combined with the first to form a new proposition such as "A canary is a bird that lives in a cage."

Procedural knowledge, on the other hand, is thought to be organized within a network of productions (Anderson, 1983). Productions resemble computer language IF-THEN statements, with the condition of a production being some pattern of data or some sequence of actions. Productions allow classification of new instances of concepts based on a pattern, as in the following example:

IF person 1 is the mother of person 2
    AND person 2 is the mother of person 3
THEN person 1 is the grandmother of person 3.

This production would apply if the current contents of STM was "Mary is the mother of Judy" and "Judy is the mother of Sally". The system would then make the inference that "Mary is the grandmother of Sally", and that conclusion would be deposited in short-term memory for further processing (Goldman, 1986).

Productions also allow some sequence of actions, either mental or physical or both, to be taken if conditions of the production are met. These actions will only be undertaken if the pattern-recognition portion of the production is satisfied, as in the following example:

IF figure is two-dimensional
    AND figure has three sides

AND one angle of figure is 90 degrees
THEN determine length of sides adjacent to right angle
AND square each length
AND sum the squares
AND take square root to determine length of hypotenuse.

From this example, it is apparent that pattern-recognition productions and action-sequence productions are interrelated. Recognition of patterns is prerequisite to performing actions, implying that declarative knowledge is necessary in order to develop procedural knowledge. Similar networks of productions may exist for instructional design situations, and the designer utilizes these rules in making decisions regarding various aspects of the problem. For example, a production such as the following might help to determine an appropriate strategy for instruction:

IF many students
AND little money available for materials
THEN use lecture to deliver information.

If the pattern of problem information matches the conditions of the production, the designer will make the choice of lecture for the instructional strategy.

The human memory system also has amazing capabilities to integrate information, make conclusions based on incomplete information and understand complex concepts and relationships. These abilities vary from individual to individual and also take time to develop. The processes which serve to integrate information and make inferences from incomplete information are necessary because of the limitations of short-term memory in handling information. Therefore, people often rely on general knowledge acquired in previous situations to help encode and retrieve information. In fact, prior knowledge plays a major role in constructing meaning from new information, and reconstructing information during recall. The framework in which this knowledge is organized is known as a schema (Bartlett, 1932).

Schemata can be thought of as basic descriptions of general knowledge which select and modify experiences in order to achieve a consistent, coherent representation of

experiences (Alba & Hasher, 1983). Since Bartlett's original work, many researchers have investigated higher-order knowledge structures for events (Schank & Abelson, 1977), stories (Rumelhart, 1975), objects (Posner & Keele, 1968), and scenes (Mandler & Johnson, 1976). From this and other research, a view of schema as networks combining many different propositions and productions about a particular topic or situation has emerged.

In general, this research has identified three basic characteristics of schemata. First, the description provided by a schema is fairly general. As information is received, the schema is filled-in, or instantiated, with the pertinent details of the current situation. Second, schemata are stereotypical descriptions which aid in processing the information, and not every situation will exactly "fit" a particular schema. Finally, schemata can be described as a hierarchy of components, with more general aspects of the situation at the top of the hierarchy, and more specific components below.

Problem Solving

People are often confronted with situations in which neither the information stored in long-term memory nor the constructive processes of memory are sufficient to reach a particular goal. In these cases, the goal must be attained by identifying means for transforming particular aspects of the situation, or in other words, to solve the problem. Newell and Simon (1972) have developed a theory of human problem solving based on the information processing model just described.

Given the processes and limitations of the human information processing system, Newell and Simon (1972) identified the important characteristics of human problem solving which influence the task, including the task environment, the mental representation of the problem and selection of appropriate operations. Essentially, the problem solver integrates information from the task environment and the problem in establishing a problem space. The problem-solving process then proceeds by means of a search of the problem space for

appropriate operations which may transform the information in the problem space into a state which meets the goals of the solution.

The task environment encompasses the problem description, including the context of the problem as well as any information, requirements or constraints that might be applicable to the problem. The prior knowledge of the individual problem solver can greatly affect the perception and organization of information from the task environment, as well as influencing the subsequent representation of the problem in memory.

The mental representation, or problem space, developed by the problem solver contains ideas or hypotheses regarding possible solutions along with the representation of the problem. The problem space is developed through interaction with the information in the task environment, and consists of a set of elements (symbol structures) which represent states of knowledge about the task, and a set of operators which are information processes that produce new states of knowledge from existing states. The problem space changes during the course of problem solution through interaction with operators which are applied by the problem solver in order to progress from the initial problem state to the goal state.

The success of an individual problem solver is related to prior experience with the problem domain. A significant amount of research on expert and novice problem solvers has shown that expertise is a major factor for successful problem solution. Studies have found significant differences in problem solving abilities between experts and novices in such domains as chess (Chase & Simon, 1973), physics (Chi, Glaser, & Rees, 1982; Larkin, McDermott, Simon, & Simon, 1980) and computer programming (McKeithen, Reitman, Rueter, & Hirtle, 1981). In general, these studies show differences in task performance and problem representation. Experts tend to chunk or organize information in more highly structured patterns, to employ different strategies, to use different procedures and to complete the solution of domain-specific problems more quickly than novices. Experts represent problems differently than novices because of their superior ability to

recognize patterns, infer relationships, disregard irrelevant information and recall similar problems from past experience. In terms of design, experts have developed networks of productions which help them to recognize features of the current problem which are similar to previous problems, and have stored various solution possibilities or plans for each feature.

Ill-Structured Problems

Much of what is known about problem solving has been discovered through experiments involving problems which are well-specified, such as math problems, variations of "Missionaries and Cannibals" or the "Towers of Hanoi". Many other problems, however, are not as easily solved because of an ill-structured nature (Reitman, 1964). Though there may be an ultimate goal for an ill-structured problem, the intermediate goals are often unclear, and the exact configuration of the final state is not known. Furthermore, procedures for solution are not readily available, and the problem space may be subjected to nearly unlimited transformations (Simon, 1969).

When ill-structured problems such as design are encountered, the processes of problem solving must be adjusted to accommodate the "fuzzy" characteristics of the problem. Simon (1973) identifies two central processes for solution of ill-defined problems: evaluation of specifications and coordination of problem-solving effort. A prime example of these processes can be found in studies of the planning process and decision making.

Planning. Newell and Simon (1972) view planning as an auxiliary problem-solving activity which can provide an algorithm for the actual solution of the problem. Plan construction can guide the action in the problem space through abstraction of details from original objects and operators, formation of a similar abstract problem, solution of this abstract problem and translation of the planned solution back to the original problem space for execution.

An alternative model of planning that is less rigid than the top-down approach described by Newell and Simon (1972) has been proposed by Hayes-Roth and her colleagues (Goldin & Hayes-Roth, 1980; Hayes-Roth, 1980; Hayes-Roth & Hayes-Roth, 1979; Hayes-Roth, Hayes-Roth, Rosenschein, & Cammarata, 1979; Hayes-Roth & Thorndyke, 1980). In this model, planning is described as "opportunistic", where prior decisions at various levels of abstraction influence the current decision to be made. The major contentions of this model are that planning occurs at several levels of abstraction, and that the planner moves between these levels in no predetermined order. In other words, the planning process is not top-down, but multi-level.

By partitioning the planning process into various levels of abstraction and allowing for multi-directional processing, the opportunistic model provides greater flexibility than the top-down approach. The computer model assumes that many distinct "specialists" apply their particular knowledge in making decisions at one of five levels of abstraction, including plan, knowledge base, plan abstraction, meta-plan, and executive levels. These decisions are recorded on a data structure called a "blackboard", and links are established between logical or causal relationships of the various decisions. The blackboard allows the knowledge specialists to interact and communicate at any of the various levels of abstraction.

Hayes-Roth and Thorndyke (1980) examined decision making from the perspective of the opportunistic planning model, finding that people do indeed plan at different levels, and that the current decision to be made is strongly influenced by the three or four most recent decisions that have been made, regardless of the level of abstraction. By imposing constraints, the experimenters showed that decisions made early in the planning process influenced subsequent decisions at both higher and lower levels of abstraction. Finally, by requiring certain decisions at the outset, subjects were forced to adopt either a bottom-up or top-down approach to subsequent planning decisions.

Decision-Making. Early research in decision making focused on statistical models of optimal choice, as exemplified by most behavioral decision theories, where people's decisions are based on expected worth or utility of information with respect to their personal values (Fischhoff, 1988). More recently, the goal concept in decision theory has generated a new line of research based on cognitive theories (Jungermann, von Ulardt, & Hausmann, 1983). Thus, the focus has changed from well-defined problems where the options are given and analysis concentrates on approaches to selection and evaluation of options, to ill-defined problems where options must be generated by the decision maker.

In ill-defined situations such as design, decision making follows a process of establishing a cognitive goal hierarchy that can be activated by impersonal and personal associations which the decision maker brings to the task. The decision actions taken, then, are related to the personal preferences of the decision maker and are influenced by goal explicitness and importance (Jungermann, von Ulardt, & Hausmann, 1983).

When considering information related to the situation, decision makers often incorporate additional information that is not presented in the problem (Huber, 1983). This makes research in this area difficult, as the information presented in the task may be interpreted and combined with the information stored in the decision maker's own memory. Therefore, the amount and properties of the information in memory affect the representation of the decision task (Huber, 1983).

Another area of research has examined decision making in clinical judgment settings (Fischhoff, 1988). In these studies, decision-making strategies have been identified based on cues the judges consider. Bruner, Goodnow and Austin (1962) identified several of these strategies in their studies of cue selection in various classification and problem-solving tasks. They have identified four categories of strategies which people use to access appropriate information, ease the difficulty of organizing information and mitigate the risk involved in making incorrect choices. Simultaneous scanning is employed when

people identify one cue that eliminates certain possibilities, and then judge the remaining cues based on how they might further eliminate other possibilities. A successive scanning strategy identifies one cue, and then examines all instances where that cue applies. Conservative focusing selects one cue, and then makes a sequence of subsequent choices where only one attribute is altered, until a match is found. Finally, focus gambling uses a positive cue as a focus and then changes several attributes at a time until all attributes correspond to the desired state.

The utilization of cue selection strategies has been shown to reduce the cognitive strain of the decision maker as well as regulating risk (Bruner, Goodnow, & Austin, 1962). When decisions must be made in sequences where early decisions can affect later decisions, strategies help to attain certain objectives or goals. Decision makers are readily able to alter strategies, choose methods for gathering information that are appropriate to the situation and combine partially valid and conflicting cues when necessary.

The Cognitive Processes of Design

Even though a problem may be ill-structured, the basic stages of problem solving are still evident. The difference is that procedures and strategies for solution must be adjusted to accommodate the vague characteristics of the problem. As noted by Simon (1973), design is a prime example of ill-structured problem solving. Design is controlled by a schema for processing problem information and developing specifications during the early stages of the problem. As the process continues, other schemata are evoked from memory as they are needed for various sub-problems. The whole process of design, then, involves breaking an ill-structured problem apart to the point where each sub-problem has precise characteristics, and subordinate schemata can be brought to bear in solving the sub-problems.

Studies of architectural designers have reported examples of the cognitive processes employed in the design process (Akin, 1979; Eastman, 1968, 1972). Two distinct

behavioral categories emerge from such research: problem structuring and problem solving (Akin, Chen, Dave, & Pithavadian, 1986). Problem structuring transforms the information obtained through functional analysis into ideas that must be satisfied in the final solution. These ideas are generated in the form of scenarios which partition the design space into a hierarchical organization of design units, along with the parameters of the units and relationships between units (Akin, Chen, Dave, & Pithavadian, 1986). Furthermore, the structure of the problem can affect the designer's performance. When the information of a design problem is provided in a more hierarchical structure, solutions tend to be faster, more clustered, stable and more successful in satisfying design requirements (Carroll, Thomas, Miller, & Friedman, 1980).

For example, when designing an office suite, the designer begins by identifying the necessary components and relationships (amount of space, number of rooms, personnel interaction, access relationships, etc.), and then develops a hierarchy of "design units" such as the secretary's area, the office manager's area, space for other staff, and a conference room. These design units are then arranged in various ways until a solution is found which meets the requirements and constraints established earlier (Akin, Chen, Dave, & Pithavadian, 1986). In the case of instructional design, the designer identifies design units which might include the learner, the content or task to be learned and the environment of the learning situation. By analyzing the characteristics of these design units, and by identifying constraints and resources which will impact on the arrangement of the design units, the instructional designer is structuring the problem.

Problem structuring establishes the problem space, while problem solving completes the design task by deriving solutions which satisfy the requirements and constraints for each design unit. Solution proceeds under a control structure that is established through problem structuring, and consists of successive generate/test actions which progress toward the final solution. Problem solving in design also contains a feedback component

which communicates results of the solution to higher levels, where restructuring of the problem space can be undertaken if the partial solution demands such an action (Akin, Chen, Dave, & Pithavadian, 1986). For example, after the instructional designer has established the basic structure of the problem and begun to develop a solution, new information regarding the learners may be obtained through formative testing. This new information would then be used to revise the solution, and may even cause the designer to reject the current solution and begin another iteration of problem structuring.

Akin (1979) has noted other interesting phenomena which occur during the architectural design process. First, the designer's attention does not focus on a single issue for more than ten minutes. Initially, attention is directed toward external stimuli and cues given in the problem statement, but later, attention is controlled by internal processing. Second, all facets of the problem are considered numerous times. Each time a new issue is attended to, a new solution or goal is developed. Decisions are made with respect to an issue, and then the problem is reconsidered in light of the decision. Finally, the degree of success of the process is evaluated at approximately fourteen-minute intervals. It would appear that the design process is circular or spiral (Banathy, 1987), with a cycle of structuring, solution, and evaluation occurring at regular intervals (Akin, 1979). Eastman (1968) has referred to these stages as identify, test and manipulate.

These design characteristics coincide with Akin's observation that design protocols exhibit an inherent hierarchy where the overall context of the design is first understood before the subsequent issues of organization or solution are considered. The opportunistic planning model (Hayes-Roth & Hayes-Roth, 1979) would predict this type of cognitive activity because, at the outset, decisions regarding the overall scope and structure of the problem would be more likely than decisions about specific aspects of the solution.

The success of initial understanding and problem specification is directly related to the designer's experience and knowledge in the problem domain. Akin (1979) has observed

that environmental cues can evoke a precompiled solution from the designer's memory very early in the process, indicating the influence which declarative and procedural knowledge structures have on the design process. Jeffries, Turner, Polson, and Atwood (1981) contend that a general design schema containing the overall structure of a design and the processes necessary for generating that design exist for individual software designers. The general schema controls the process of problem decomposition, as well as evoking other subordinate schemata for each sub-problem. After each sub-problem is solved, another schema is retrieved to tie together the various solutions in order to form the final design. The study reported significant similarities between schemata of experienced designers, although individual differences were found because of prior experience with software design.

Similar knowledge structures have also been identified for instructional designers. McCallin (1986) found that experts' conceptual organizations of a well-published model of the design and development process was more consistent than novices' conceptual organizations. Nelson (1987) found similar results with respect to design procedures and memorial processes. Expert designers represent instructional design activities within a script that is more abstract and compact than novices. In addition, experts tend to chunk information in more highly structured patterns, and are able to recall relevant information more effectively.

In summary, it is apparent that design can be viewed as a problem-solving process with special characteristics which derive from the ill-defined nature of design problems (Reitman, 1964). Designers, therefore, must develop ways of breaking the problem into smaller units which can be tackled separately (Simon, 1973). Cognitive structures which control the process of problem decomposition allow the designer to focus on the details of the problem rather than the process (Jeffries, Turner, Polson, & Atwood, 1981). Furthermore, specific domain knowledge enables the designer to solve sub-problems in

prototypical ways based on prior experience (Akin, 1979; Eastman, 1972).

It can be expected that instructional designers will employ processes similar to those of designers from other areas, due to the nature of the human information processing system. While studies of other types of design provide some insight into these processes (Akin, 1979; Akin, Chen, Dave, & Pithavadian, 1986; Eastman, 1968; Jeffries, Turner, Polson, & Atwood, 1981), it is likely that the instructional design process differs from architectural or computer software design. Problem solving research suggests that there may be similarities, but since expert problem solvers from different domains operate differently (Newell & Simon, 1972), it is necessary to investigate the instructional design process in more detail.

An appropriate starting point is to examine the information that instructional designers use to make decisions during the problem-structuring phase of the process, where specific details or constraints may cause a particular solution to be identified early in the process. Instructional design models tend to emphasize the importance of needs, task, content and learner analyses during the early stages of design (Dick & Carey, 1985; Gagne', Briggs, & Wager, 1988; Romiszowski, 1981). Such an approach aids in the decomposition of an ill-defined problem into more well-defined subproblems, which is characteristic of the design process in general (Simon, 1973). These procedures each require various kinds of information as specified by the particular approach to problem decomposition (Dick & Carey, 1985; Gagne', Briggs, & Wager, 1988; Reigeluth, 1983b; Romiszowski, 1981; Wileman & Gambill, 1983). But it is possible that some types of information are more critical than others for a particular analysis (Akin, 1979), and that some information is utilized for more than one aspect of problem analysis (Carroll, Thomas, & Malhotra, 1980).

Given this background, what types of information do instructional designers utilize for decision making during the initial phase of the design process, and how is the

information used in decision making? Do designers concentrate on only one aspect of the problem at a time, or do they tend to move from one area to another? What effect do various types of constraints have on the design process? In order to address these questions, a descriptive study was designed to determine which kinds of information are considered by designers as they attempt to understand an instructional design problem and develop a tentative solution. The method employed develops two primary data sources: quantitative measures of the problem information accessed during the process, and qualitative descriptions which facilitate process tracing and comparisons between different designers. Such an approach allows for a more precise description of the instructional design process than has been provided to date.

Method

Participants

Four instructional designers with experience gained from a wide variety of instructional design and development settings were chosen to participate in this study. Participants were selected in order to assure a diverse, albeit small, sample of approaches to design. All participants were employed as instructional designers at the time of the experiment. Participants were informed of the nature of the study and signed consent forms in accordance with regulations of the Virginia Tech Institutional Review Board on Research Involving Human Subjects (See Appendix A).

Participant One was a male in his mid-forties who had thirteen years of experience as an instructional designer, primarily in the design of computer-based instruction. He had worked on the design and development of the PLATO system for computer-assisted instruction, and was currently employed as the leader of a design team working on a large interactive video project at a large university. His two years of related experience involved administration of instructional facilities, and he was about to become the director of user services in the computing center of a large university.

Participant Two was a male in his late sixties who was employed for the past five years as an instructional designer in the learning resources center of a large university. His major responsibility was instructional improvement, which required him to work closely with university professors in order to redesign their courses. Prior to his current employment, Participant Two had been a college professor and academic dean for more than twenty years. In the capacity of college professor, the participant had taught courses which included units on instructional design.

Participant Three was a male in his early forties who, for the past three years, was responsible for the administration of a learning resources center at a large university. As part of his job requirements, the participant interacted with clients on more than twenty

projects each year. He was also responsible for assigning design teams to work on projects, developing budgets, pursuing funding and marketing new products. His prior experience included five years as an instructional designer and more than eight years as a producer of instructional television programs. The participant also taught instructional design as a component of an interactive video course, and had published articles focusing on the design and production of interactive video courseware.

Participant Four was a male in his early thirties who had eight years of experience in instructional design. At the time of the experiment he was employed as an instructional designer by a major accounting firm. His employment responsibilities consisted mainly of interacting with subject matter experts for the purposes of task and content analyses, product development and formative evaluation. He worked on an average of five projects per year. The participant had previously been employed for four years as a public school teacher emphasizing technology education, and had also published articles on the instructional design and technology design processes.

Materials

The instructional design task, as exemplified by the models of Dick and Carey (1985) and Gagne', Briggs, and Wager (1988), was analyzed to determine the categories of information which were most likely to be used for decision making. The categories included information about the task to be trained, the content, the skills to be developed, learner characteristics, instructional setting, time for development and delivery, the human resources available and the budget for materials. Information about an instructional design problem involving training for library personnel was then produced corresponding to these categories. Discrete units of information from the various categories were printed on one side of an index card, and a label describing the information was printed on the other side of the card (See Appendix B). A separate sheet of paper containing a list of the labels arranged alphabetically served as an index to the cards (See Appendix C). The cards were

arranged in a file box in the same order as the index, with the labels visible but not the information. Each card was marked with a code number so that it could be individually identified. Questions designed to ascertain the participants' background and experience were developed (See Appendix D). An instruction sheet for the task was also prepared for each participant (See Appendix E).

Task

In the job situation, the instructional designer may meet with clients, project managers, subject matter experts and others in the course of gathering information about the problem (Kemp, 1985). All of these sources provide information which must be considered by the designer in making decisions during the design process. The task developed for this experiment attempted to represent the design environment in such a way as to maintain some control over the information provided to the designer. That is, the designer could focus on obtaining the information necessary for decision making, rather than formulating questions to probe a client's intentions or a subject matter expert's knowledge. Since participants were not required to develop an instructional product, the task represented only the initial phase of instructional design. It was expected that as the problem was presented to the designer, various procedures involving needs assessment, goal development, identification of resources and constraints, learner analysis, and content and task analyses would occur. The participants were only required to utilize the information presented to develop "preliminary specifications" of a solution to the problem.

Information was provided to participants from four sources. First, the instructions gave general information about the task and the problem (See Appendix E). Second, the card index gave an overview of the information available in the card file (See Appendix C). Third, the information cards supplied specific information about various aspects of the problem (See Appendix B). Finally, the answers given by the experimenter to the questions asked by participants augmented the information already available from the cards

and the instructions. In addition, it was assumed that since the problem domain (a library) was a commonly known area, individual participants would bring some prior knowledge to the task, relating specifically to the job of sorting and shelving books or in general terms regarding the organization of a library.

The task was patterned after simulation techniques developed for other problem-solving research, namely clinical judgments by physicians (McGuire & Babbott, 1967; Rimoldi, 1955; Rimoldi, Devane & Haley, 1961) and fault diagnosis of electronic equipment (Glaser, Damrin & Gardner, 1960). Taking into account suggestions made by these researchers, the task was based on information of the type typically utilized by the designer, the task required a series of interdependent decisions aimed toward solution of the problem, and the task was constructed to allow variation in the designers' approaches. The participants were free to access information in any order, and to ask any questions they deemed necessary. It was assumed that a given question was asked because certain information provided by the answer was useful for the solution of the problem. Similarly, it was assumed that accessing various information cards indicated either the need for information in making a decision, or the need for clarification and elaboration of the information provided by the card index.

Procedure

Participants completed the task individually at a desk in a private office. Before the session began, a videotape camera and recorder were assembled for taping the session. After informing the participant of the nature of the session and collecting the consent form, the experimenter turned on the camera. At this time the instruction sheet, paper and pencils for note-taking, the box of information cards and the index to the card labels were given to the participant.

After reading the instruction sheet, the participant was given the opportunity to ask clarifying questions about the task. When the task was understood, the participant began

examining the cards, thinking aloud as the task proceeded. The experimenter recorded the sequence in which the cards were accessed. When additional information was necessary, the experimenter responded to questions. All responses were kept as consistent as possible across sessions, but if the question involved a proposed solution, the experimenter accepted the proposal even if it differed across sessions.

After accessing the necessary information, the participant gave a tentative solution to the experimenter verbally. Finally, the questions probing the participant's instructional design background were answered, the camera was turned off and the session was completed.

Data Analysis

Analysis of the data obtained in this study relied on two primary sources. First, a quantitative analysis based on the category and sequence of information accessed helped to determine the usefulness of particular types of information for the problem-solving process (Rimoldi, 1955). Indices of information selection, dispersion of information selected across the process, additional information requested of the experimenter and agreement between participants regarding information selected were determined. These analyses helped to describe what information was used in making design decisions.

These quantitative descriptions were supported and elaborated through a qualitative analysis of the participants' verbal reports. These verbalizations were necessary in order to further describe the characteristics of participants' problem-solving processes. Merely examining the quantitative data would not provide sufficient evidence of participants' design strategies. Following the advice of Ericsson and Simon (1984), the qualitative analysis focused on the task completed by the participants, rather than attempting to describe general problem-solving processes. The characteristics of the problem-solving process exhibited by participants were determined by producing protocols derived from transcripts of the think-aloud task. These protocols were collapsed into episodes in order

to examine how the information was considered and the decisions were made by individual designers (Newell & Simon, 1972). Frequency counts of the behaviors identified in the protocols were produced in order to describe and compare the various strategies employed by the participants. The actual transcripts were also examined in order to extract the segments pertaining to the critical incidents identified through the protocol analyses. Finally, verbal descriptions of the proposed solutions were compared to determine congruities between the solutions.

Results and Discussion

Quantitative Analysis

Information Selection

As mentioned earlier, each information card contained a code number so that the sequence of information accessed could be recorded. The selection of any particular card was interpreted as the participant's attempt to access information that was necessary for a decision at that point in the process, or the need to clarify and elaborate on the meaning of the labels from the card index sheet. Of the 104 total information cards available to the participants (26 cards x 4 participants), a total of 44 cards, or 42.3 percent, were selected. A total of 17 of the possible 26 cards were selected by at least one participant. Of the 44 total cards selected, 5 cards were selected more than once by a single participant, and 10 cards were selected by more than one participant. Table 1 presents a summary of the frequency distribution of information cards selected by all participants.

An interesting finding was obtained by analyzing the information selection by category. As mentioned earlier, the categories of information corresponded to those necessary for common instructional design models. An information selection index was computed, defined as the number of times a card in a particular category was selected divided by the total number of cards available in the category (this index excluded repeated selection of a single card by a participant). Table 2 summarizes the selection indices for the eight categories, revealing that information about the learner, time for training and the skills to be trained was considered by all participants (Selection index = 1.0). In contrast, information about the task to be trained, the content and the setting had low selection indices. This may be due to the fact that this information was not important for the initial phase of design, but as discussed in the qualitative analysis, it is also possible that the participants' already possessed sufficient knowledge of the task to be trained, the content and the setting to enable them to proceed.

Table 1.

Frequency Distribution of Cards Selected by All Participants.

Category	Label	Card Number	Participants			
			One	Two	Three	Four
Task	Shelving Cutter Numbers	18				
	Shelving Different Editions	19				
	Shelving Multiple Copies	20				
	Shelving Oversized Books	21				
	Shelving Reference Books	22				
	Shelving Reserve Books	23				
Content	Book Classification Scheme	1	√			√
	First Line of Call Number	9				
	Second Line of Call Number	17				
	Cutter Numbers	4	√			
	Editions of the Same Book	6	√			
	Multiple Copies	12				
	Oversized Books	13				
	Reference Books	15	√			
	Reserve Books	16				
Skills	Employee Evaluations	7	√		√	√
	Work Skills	26	√	√	√√√	√
	Daily Work Duties	5	√	√	√√	√
Learner	Experience of Employees	8	√	√	√√	√√
Setting	The College	3	√			√
	Patterns of Library Use	14	√			
Time	Time for Training	24	√	√	√√	
Resources	Involvement of Staff	10	√	√	√	√
	Work Assignments	25	√			√
Budget	Budget for Training Materials	2	√	√	√	
	Library Staff Budget	11	√			

Table 2.

Combined Selection Indices by Category.

Category	Total Cards Available	Total Cards Selected	Selection Index
Task	24	0	0.0
Content	36	5	0.14
Skills	12	11	0.92
Learner	4	4	1.0
Setting	8	3	0.38
Time	4	3	0.75
Resources	8	6	0.75
Budget	8	4	0.5

Participant One selected 15 out of 26 possible cards, or 57.7 percent of the information available on the cards. Selection indices were high for all categories except the task to be trained and the content (See Table 3). Participant Two selected the fewest pieces of information, only 6 out of the 26 possible cards, or 23.1 percent. The selection indices for the skills, learner and time for training categories were high. In fact, all the possible information from these categories was selected (See Table 4). The task to be trained, content and setting categories were not accessed at all. Participant Three exhibited tendencies similar to Participant Two in selecting information, using 7 of the possible 26 cards (26.9 percent), although 4 of these 7 cards were selected more than once. Again, the selection indices for the various categories show that the participant focused on information about the learner, the skills to be trained and the time for training (See Table 5). The indices for the resources and budget categories were also high, while the content, task to be

trained and setting categories received no attention. Participant Four also concentrated on information from the skills, learner and resources categories, selecting 8 of the possible 26 cards, or 30.7 percent (one card was selected twice). He also selected information about the setting and one item regarding content (see Table 6).

Table 3.

Selection Indices by Category for Participant One.

Category	Total Cards Available	Total Cards Selected	Selection Index
Task	6	0	0.0
Content	9	4	0.44
Skills	3	3	1.0
Learner	1	1	1.0
Setting	2	2	1.0
Time	1	1	1.0
Resources	2	2	1.0
Budget	2	2	1.0

Table 4.

Selection Indices by Category for Participant Two.

Category	Total Cards Available	Total Cards Selected	Selection Index
Task	6	0	0.0
Content	9	0	0.0
Skills	3	2	0.67
Learner	1	1	1.0
Setting	2	0	0.0
Time	1	1	1.0
Resources	2	1	0.5
Budget	2	1	0.5

Table 5.

Selection Indices by Category for Participant Three.

Category	Total Cards Available	Total Cards Selected	Selection Index
Task	6	0	0.0
Content	9	0	0.0
Skills	3	3	1.0
Learner	1	1	1.0
Setting	2	0	0.0
Time	1	1	1.0
Resources	2	1	0.5
Budget	2	1	0.5

Table 6.

Selection Indices by Category for Participant Four.

Category	Total Cards Available	Total Cards Selected	Selection Index
Task	6	0	0.0
Content	9	1	0.11
Skills	3	3	1.0
Learner	1	1	1.0
Setting	2	1	0.5
Time	1	0	0.0
Resources	2	2	1.0
Budget	2	0	0.0

The analysis of information selection by participants during the design task suggests that certain categories of information, mainly about the learner, the skills to be taught and the time for training were considered more frequently than other categories. This result is consistent with the models of the design process generally taught and employed (Dick & Carey, 1985; Gagne', Briggs, & Wager, 1988), except for the lack of information selected regarding the training task and the content. Since the design task used in this study represents only the initial phase of problem understanding, it might be expected that problem information related to the content and the task to be trained may not be considered during this phase of design. Typically, content and task analyses occur later in the process (Dick & Carey, 1985).

The fact that content and training task information was not selected in greater frequencies may also be due to the participants' familiarity with the problem domain (one participant remarked that "any idiot can pick up a book and put it down"). Other

researchers have found similar tendencies. Akin, Chen, Dave, and Pithavadian (1986) note that architectural designers draw upon personal experience to infer or generate missing information, and that designers bring to the problem a knowledge of how things generally ought to be. In the case of designing training for librarians, it is possible that the same thing is happening.

Additional Information Requested

Identification of the information utilized by the participants can also be elaborated by categorizing the additional information requested by individual participants. Table 7 summarizes the frequency of requests by category, again showing that of the 28 total requests, 27 (96.4 percent) were for information from the skills, learner, setting and resources categories. The other request was for information about the time for training. It is interesting to note the "practical" nature of the additional information requested by participants, especially Participants Three and Four, who asked questions pertaining to the need for instruction, the time for development and the skills to be trained. Summaries of the participants' questions and the information provided by the experimenter are given in Tables 8, 9, 10 and 11.

Table 7.

Frequencies of Additional Information Requested by Category.

Participant	Category							
	Task	Content	Skills	Learner	Setting	Time	Resources	Budget
One			1					
Two							1	
Three			2	1	5		1	
Four			7	2	6	1	1	

Table 8.

Additional Information Requested by Participant One.

Time from Beginning of Task	Question	Experimenter's Response
7:19	Do they come in as freshman and work four years?	We will train 8 students per semester

Table 9.

Additional Information Requested by Participant Two.

Time from Beginning of Task	Question	Experimenter's Response
6:42	Who's doing the training?	Librarians in a workshop, just before the semester begins

Table 10.

Additional Information Requested by Participant Three.

Time from Beginning of Task	Question	Experimenter's Response
0:20	Are these existing staff?	No
0:42	Who's doing the work now?	Current library staff
0:53	Why add more people?	Current staff is overworked
2:12	Is it necessary for us to develop the skills?	Refer to Card #26 - Work Skills
3:12	Constantly training new people?	Probably once a semester 8 new people will be added
3:25	This is a college or University library?	Yes
4:00	Is this from scratch?	Yes
4:12	How many days out are we?	We have 3 months
6:30	How did the skill list get developed?	Staff developed the list themselves
6:45	Was the skill list verified?	Not formally
7:40	Are they full-time employees?	Part-time, 20 hrs./week
9:40	The skill list was brainstormed?	Yes
9:50	How did work duties get developed?	Through self-observation by staff
10:07	Did one person develop the list?	Yes, validated by the rest of the staff
10:18	There's a group consensus?	Yes
15:19	Do these criteria already exist?	Yes, for work-study people in other departments
16:45	Do you want us to give you the final package?	Yes, we will help revise

Table 11.

Additional Information Requested by Participant Four.

Time from Beginning of Task	Question	Experimenter's Response
1:00	Where does my unit fit in the overall program?	A portion of a two-day workshop held just before school begins
1:44	What level of competency do you expect?	To know the basics, but probably still need practice
3:07	What's the background of these people?	Refer to Card #8 (Experience of Prospective Employees)
6:50	How often do they work?	20 hours/week
10:02	Have you had that kind of success?	No. We tend to check shelves for lost books whenever possible
10:25	Would you like to have some more efficient way of doing that?	Not as part of this project
13:39	When was the last time you did training on this?	This is the first time
13:42	Do you have anything that indicates how it's done?	Never any work-study employees until this program
14:26	Have any other areas used work-study?	Yes, clerical work, maintenance, etc.

Dispersion of Information

Although there was no time limit for completion of the task, a time-based analysis of the sequence of information considered provides a further description of the design processes employed by the participants. As shown in Tables 12 and 13, Participant One accessed information sequentially as it was organized in the box, therefore the dispersion across categories shown in Table 13 is due primarily to the alphabetical organization of the card labels. The participant flipped through the cards sequentially from the front to the back of the box, classifying the information as it was encountered and making notes when necessary. The participant remarked that this approach was not too far from the actual interview process he usually followed, where:

> ... as I'm listening to a client, they wander all over the landscape. So I'll draw balloons. I put down an idea or thought, I don't know where it goes yet, and another over here. If it looks like it might be related to that, I'll put it nearby and draw a little line to make connections. So in a sense, that's what I'm doing here.

As can be seen in Table 12, the participant deviated from the sequential selection of items after reaching Item 11, remarking that items 16 through 23 were "all just content stuff."

Participant Two followed a different sequence, one that was more predictable in terms of accepted models of instructional design. As Tables 14 and 15 show, this participant first determined what skills were to be taught, followed by information about the learner, the budget and the resources available. Each of these items of information were selected only once, however (by contrast, Participants Three and Four selected some of the same items repeatedly).

The sequence of information selected by Participant Three is similar to that of Participant Two. Although consideration of skills and learner categories are reversed, these categories appear to be important at the beginning of the task (See Tables 16 and 17). This assertion is supported by the tendency of Participant Three to reexamine these items

throughout the process. As Table 17 shows, information about work skills and work duties was reexamined six times after the initial access which occurred very early in the process (during the third minute).

The importance of the learner and skills categories are further supported by the sequence of information selected by Participant Four. This participant also followed a sequence similar to Participants Two and Three, beginning by considering information about the learners, the setting and the work skills (See Tables 18 and 19).

Table 12.

Dispersion of Individual Information Items Selected by Participant One.

Elapsed Time (In Minutes)	Item Accessed (Card Number)
1	Book Classification System (1), Budget for Training (2)
2	The College (3), Cutter Numbers (4)
3	Daily Work Duties (5)
4	Editions of the Same Book (6), Employee Evaluations (7)
5	Employee Experience (8)
6	Involvement of Staff in Training (10)
7	Library Staff Budget (11)
8	
9	
10	Library Use (14), Reference Books (15)
11	Time for Training (24), Work Assignments (25), Work Skills (26)

Table 13.

Dispersion by Category of Information Selected by Participant One.

Elapsed Time (In Minutes)	Category							
	Task	Content	Skills	Learner	Setting	Time	Resources	Budget
1		√						√
2		√			√			
3			√					
4		√	√					
5				√				
6							√	
7								√
8								
9								
10		√			√			
11			√			√	√	

Table 14.

Dispersion of Individual Information Items Selected by Participant Two.

Elapsed Time (In Minutes)	Item Accessed (Card Number)
1	
2	Work Skills (26)
3	
4	
5	Employee Experience (8)
6	Budget for Training (2)
7	Involvement of Staff (10)
8	
9	
10	
11	Work Duties (5), Time for Training (24)

Table 15.

Dispersion by Category of Information Selected by Participant Two.

Elapsed Time (In Minutes)	Category							
	Task	Content	Skills	Learner	Setting	Time	Resources	Budget
1			√					
2								
3								
4				√				
5								√
6							√	
7								
8								
9								
10			√			√		

Table 16.

Dispersion of Individual Information Items Selected by Participant Three.

Elapsed Time (In Minutes)	Item Accessed (Card Number)
1	
2	Employee Experience (8)
3	Work Skills (26), Time for Training (24)
4	
5	Budget for Training (2), Involvement of Staff (10)
6	
7	
8	Work Skills (26)
9	Time for Training (24), Work Duties (5)
10	Work Duties (5), Work Skills (26)
11	
12	Employee Experience (8)
13	Work Skills (26), Work Duties (5)
14	
15	
16	Employee Evaluation (7)

Table 17.

Dispersion by Category of Information Selected by Participant Three.

Elapsed Time (In Minutes)	Category							
	Task	Content	Skills	Learner	Setting	Time	Resources	Budget
1								
2				√				
3			√			√		
4								
5							√	√
6								
7								
8			√					
9			√			√		
10			√√					
11								
12				√				
13			√√					
14								
15								
16			√					

Table 18.

Dispersion of Individual Information Items Selected by Participant Four.

Elapsed Time (In Minutes)	Item Accessed (Card Number)
1	
2	Employee Experience (8)
3	The College (3)
4	Work Skills (26)
5	Involvement of Staff in Training (10)
6	
7	Book Classification System (1)
8	
9	
10	Employee Evaluations (7)
11	
12	Employee Experience (8)
13	Work Assignments (25)
14	Daily Work Duties (5)

Table 19.

Dispersion by Category of Information Selected by Participant Four.

Time In Minutes	Category							
	Task	Content	Skills	Learner	Setting	Time	Resources	Budget
1								
2				√				
3					√			
4			√					
5							√	
6								
7		√						
8								
9								
10			√					
11								
12				√				
13							√	
14			√					
15								
16								

Considering the diverse backgrounds and experiences of the participants, the similarities in the sequences of information accessed are interesting. Figure 2 represents a composite graph of the sequences of information considered by each designer. Note the clustering of categories that is circled. At the outset, the skills and learner categories were considered, followed by resources, and then a reconsideration of skills. With 26 items to choose from, the probability of choosing so many similar items is very low. The fact that the order does not agree is not as important as the fact that the items were chosen at all. These choices support the notion that some categories of information were more important than others for the initial phase of instructional design, and that the participants utilized similar processes to organize and control the establishment of the problem space.

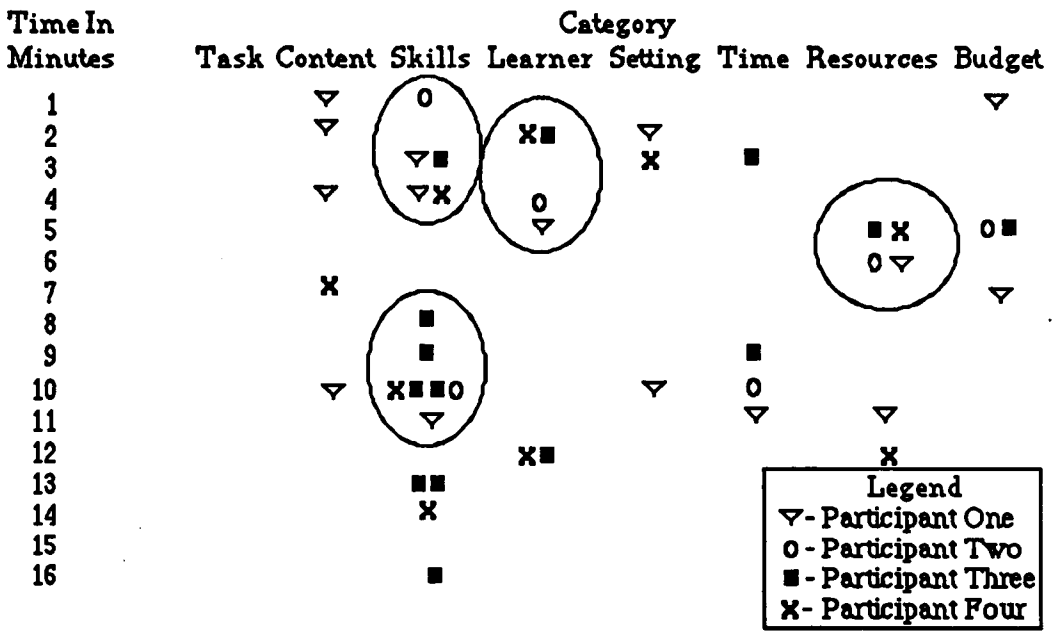

Figure 2. Combined Dispersion of Information Selected by Participants.

Qualitative Analysis

With the important information categories described, it is now possible to examine in greater detail how the information was used by each participant. The discussion which follows is based on the episodes from the protocols of the individual design sessions. The general procedure for analysis of the qualitative data was described earlier, but it is necessary to reiterate and expand that description before presenting the results. The transcripts of the videotaped sessions were analyzed to determine the types of processes which occurred and the information on which these processes were operating. These processes included behaviors and information which are summarized in Table 20.

Table 20.

Behaviors of Participants Identified in the Protocol Analyses.

Behavior (object)	Description
ASK (question)	Asking a question of the experimenter
CLASSIFY (information)	Making conclusions about, or classifying information
DECIDE (topic)	Making a decision about a specific topic
EXPLAIN (topic)	Explaining a decision, procedure, etc.
GOAL (topic)	Explicitly stating a specific goal
PLAN (topic)	Describing a particular aspect of a solution
READ (information)	Reading information contained on a card, the index or the problem statement
RECEIVE (information)	Receiving information from the experimenter in response to a question
RULE (topic)	Expressing a rule used to make a decision
SUBGOAL (topic)	Establishing a subgoal related to a specific goal
WRITE (information)	Writing notes about a specific topic

The protocols derived from the analysis of the transcripts, organized sequentially by time, are presented in Appendices F, G, H and I. The protocols were also separated into episodes representing the various categories of information that were considered by the participant. Significant portions of the actual transcripts are presented in the discussion which follows in order to better distinguish what information was used by the participants, and how the information was transformed.

A general description of the processes the participants employed can be made by examining the frequencies with which the behaviors listed in Table 20 occurred. Table 21 presents a summary of these frequencies for each participant. As can be seen, there were significant differences in the ways that the participants completed the task. Of course, some of the behaviors are dependent on others, as in the case of ASK and RECEIVE. Also, CLASSIFY, GOAL, PLAN and SUBGOAL involve decision-making processes. It is interesting to see the differences in the processes which resulted from the general approach to the task taken by the participants. Participants Three and Four generally acquired information through questioning, while Participant One relied on reading and classifying.

Table 21.

Frequencies of Specific Behaviors for Each Participant

Participant	Behavior										
	Ask	Classify	Decide	Explain	Goal	Plan	Read	Receive	Rule	Subgoal	Write
One	1	16	0	2	2	6	21	3	0	6	8
Two	1	9	4	1	8	8	11	2	2	0	3
Three	18	6	1	0	3	16	15	17	0	0	7
Four	9	3	2	0	4	14	10	10	0	0	3

The Design Process of Participant One

As described earlier, Participant One's approach to the task differed considerably from the other participants, consisting mainly of a sequential selection of the information as it was organized in the box. A more detailed description of the process followed by the participant can be developed through examination of the think-aloud protocols (See Appendix F). Participant One preferred to work toward developing a kind of "metastructure" which facilitated the organization and classification of the problem information. This "metastructure", as the participant referred to it, consisted of three separate areas: content, process and "logistics" or environmental concerns.

P1S1: I'm going to try to get some kind of metastructure going ...
P1S2: ... I'm thinking in my mind I'm going to teach this sorting and classification so now I'm going to figure out what all these things mean.

P1S21: I guess as I'm kind of building this overall thing, I'm going to be separating stuff into what's content...(Writes on notes)
P1S23: ... there's probably going to be some process stuff in here, you know, how you do stuff. (Writes on notes)
P1S24: But then there's going to be some demographics, logistics, environmental considerations.
P1S25: So now I'm grouping this stuff.

*Note: In this and all subsequent reproductions of the transcripts, participants are indicated by the letter P and a number (P1 is Participant One). The segment from the transcript is indicated by the letter S and a number (S1 is segment 1). The letter E indicates information provided by the experimenter

As the information was read from the cards, it was classified by the participant as belonging to one of the three areas identified, or it was simply assimilated as an odd data point that did not fit the categories, but might later. It seems apparent that the participant used this approach to build the initial problem space, and as the process continued, the problem space evolved as subsequent information was considered.

P1S38: OK, Editions of the same book, that's going to be content, I can just tell that.
(Reads Card #6)
P1S39: Employee evaluations, what's that got to do with it?
(Reads Card #7)
P1S40: OK, so we're going to keep a record of student performance on these tasks.
P1S41: So that's evaluation, I'm not sure where to put it yet.
(Writes on notes)
P1S42: Experience, who you gonna hire?
(Reads Card #8)
E: We'll hire college students as work-study.

P1S59: (Reads heading of Card #9) First line of call number...that's content.
P1S60: Involvement of staff in training.
(Reads Card #10)
P1S61: OK, so you've got to do this as an overload.
P1S62: That's a cultural/environmental kind of thing.
(Writes on notes)
P1S63: Because if you design a training program,...
P1S64: ...you've got to deliver in a time and place that's convenient, or at least acceptable, to employees.

After nearly seven minutes of this classification activity, the participant encountered information which caused a shift in the design process. The number of students to be taught combined with the budget available for materials were identified as constraints which keyed a possible solution. The participant remarked:

P1S80: That tells you...if I've got to train 9000 students with $300...
P1S81: ...I'm going to do lecture.
P1S82: If I only have to do 8 students a semester, OK...
P1S83: ... I'll spend more money on media and materials.
P1S84: Still, I'm not going to do anything elaborate,...
P1S85: ...I'm not going to buy computers and put them in there unless I can get them free.
P1S86: It's going to be fairly simple, traditional, probably lecture...
P1S87: ...maybe some exercises, paper and pencil.
P1S88: But you talk about the budget and the size of the audience,...
P1S89: ...right there you can begin to constrain what your training options are going to be.

The session then continued as before, with more information being accessed and classified. The four minutes following the identification of a major constraint were spent

mainly in scanning the index of cards, as if a decision had already been made, and the subsequent consideration of information was done mainly to verify that no other conflicting information was present.

P1S103: (Reads label) Oversized books, content.
P1S104: (Reads label) Patterns of library use?...
(Reads Card #14)
P1S105: So, peak hours, when do you work.
P1S106: I don't know what to do with that.
P1S107: Reference books.
(Reads Card #15)
P1S108: OK, that's content.
P1S109: Reserve books, that's content.
P1S110: (Reads Index) Oh, you've got these things divided up here.
P1S111: So all these things, they all run in parallel.
P1S112: Cutter numbers, different editions and all those things up in one section...
P1S113: ...then you've got shelving...
P1S114: ... so there's my division between content and process.

Finally, after a short time of reviewing the written notes in order to confirm the organization of information into content, process and logistics categories, the participant was ready to present the solution.

P1S123: Now let me see what I just did.
(Writes on notes)
P1S124 I've got the content...
P1S125: ... and a bunch of stuff about the actual process.
(Looks at index)
P1S126: And these things like work skills and work assignments,...
P1S127: ... and maybe even that thing, #14, patterns of library use,...
P1S128: ... those things to me are sort of environmental.
P1S129: They define how and when you will do the process of shelving...
P1S130: ... and what are the rules,...
P1S131: ... and kind of those things.
P1S132: So there may be three...
P1S133: ... now I'm starting to see the training.

The most clear-cut finding from this analysis was the way in which the constraints that were identified influenced the classification of subsequent information acquired. The budget and size of audience constraints established a particular solution possibility. In other words, a production rule was triggered which moved the problem-solving process

into a different state where subsequent information must either refute the conditions (constraints), or adapt to the conditions of the current production (Anderson, 1983). Hayes-Roth and Hayes-Roth (1979) also predict such behavior in their "opportunistic" planning model. Prior decisions affect current decisions, and since no subsequent information refuted the conditions, the solution established early in the process was retained.

The Design Process of Participant Two

The process employed by Participant Two was more predictable than Participant One, in the sense that it proceeded in well delineated episodes which concentrated on various aspects of the problem such as the purpose, the learner, the skills, and so on (See Appendix G). The process utilized fewer items of information and took less time to complete than Participant One. As indicated in the literature, this systematic approach to the problem was expected (Banathy, 1987; Churchman, 1968; Gagne', Briggs, & Wager, 1988; Romiszowski, 1981; Simon, 1973), and the results of the qualitative analysis confirmed these expectations. In general, the participant followed a systematic building of the problem space by examining information from various categories. In the course of reshaping the problem space, the problem information was combined with knowledge gained in previous design situations.

Participant Two first scanned the information index, and made assumptions about the problem from the cues provided there. The first three minutes were spent in confirming these assumptions and elaborating on the task goals related to the three areas the participant identified as important: knowledge of the library system (content), skills and attitude.

P2S1:	I don't see any information here on the purpose. (Scans Index)
P2S2:	... this is all content stuff, right?
P2S3:	There's a resource there and the college is there, but mostly it's content, what you want them to learn.
P2S4:	OK, the first thing I want to know is what you want to happen, ...

P2S5: ...and what you want to do is skills in sorting and shelving, right?
E: Yes.
P2S6: Let me write that down.
P2S7: And then we want to know subskills, so this means ...
P2S8: ...certain knowledge of system, etc. (Writes on Notes) ...
P2S9: ... and those knowledges and stuff I can look for in here ...
(Reads Index)
P2S10: ... under daily work duties, that would be a starting point, ...
P2S11: ... and then these various things about what to do with special cases, oversized books and so on and so on.

P2S13: Different kinds of books, call numbers and the meaning of the different numbers...
P2S14: ... so that is going to be the content ...
P2S15: ... and that would all be in the knowledge of the system.
P2S16: I don't see anything about skills, although we've got a card here for that, so let's see what is required.

Since there was no information about attitude available, the participant inferred that basic attitudes relating to job performance and dealing with patrons would be appropriate. The only information accessed from the box during this episode was the skills to be taught. All other information was derived from the cues given by the index and the prior experience of the participant. This information was used to transform the problem space by refining the problem goals.

P2S22: ...and the third thing, any attitude, is there anything relating to attitude?
(Scans Index)
P2S23: OK, then I want to know attitude formation desired ...
P2S24: ... and this would include things like attitude toward customers ...
P2S25: ...what is expected in the line of punctuality.
(Scans index)
E: That's not in there.
P2S26: Overall you probably want to encourage operations ...
P2S27: ... cheerfulness ...
P2S28: ... prepared to answer questions ...
E: Yes.
P2S29: So that up here we've got a dual purpose...
(Writes on Notes)
P2S30: ...prepare to do job, ...
(Writes on Notes)
P2S31: ...and prepare to deal with customers (Writes on Notes)...
P2S32: ...which is answer questions and what not, ...
P2S33: ...which would involve knowledge maybe beyond what you needed to do the actual job ...
P2S34: ... so that you could say "you go to the 3rd floor".

Next, the participant focused on the audience for the instruction. Again, assumptions were made based on the information accessed, specifically that some vocabulary would need to be taught because the students were "naive".

P2S37: The second thing I want to know is what kinds of people are we asked to teach this to?
P2S38: Are they students working part-time?
P2S39: Have they had any experience in the library?
P2S40: Are they freshmen?
P2S41: That sort of thing.
E: Card #8 will tell you that.
(Reads Card #8)
P2S42: So, none have worked in a library before, so we've got neophytes.
P2S43: It doesn't say whether they are students or not.
P2S44: Let's see if there's anything else we can learn about the employees.
(Scans Index)
P2S45: OK, so what we're talking about here is a naive audience.
E: Yes.
P2S46: So that part of our task, one of the consequences of this...
P2S47: ... there may be the need to straightforwardly teach them vocabulary.
P2S48: What librarians use that other people don't know.

Finally, the participant concentrated on the resources available for the training program. The budget was classified as "not much, just enough for some materials". Information about involvement of staff in the training program prompted the participant to ask whether self-instruction might be viable. When this option was confirmed, the participant immediately began to describe a solution based on such an approach.

P2S53: OK, then the next thing we want to know is the schedule ...
P2S54: ... and the resources available.
P2S55: Now let's see, first of all we've got a budget.
(Reads Card#2)
P2S56: OK, this 300-500 dollars, I don't know whether you're paying salaries or not.
P2S57: That wouldn't be very much if you're paying salaries.
P2S58: But you're probably not.
P2S59: This is probably for the cost of training personnel.
E: Yes.
P2S60: What else do we have?
(Scans Index)
P2S61: "Daily work duties" ... that isn't what we want at this point.
P2S62: "Involvement of staff in training", I should look at that.
(Reads Card #10)

P2S63: OK, a minimum.
P2S64: I suppose that means that you don't have a director of training.
P2S65: Who's doing the training?
E: We hope that the librarians can serve as instructors in a workshop, right before school starts in the fall.
P2S66: Now, at this point, given what it says on #10, an option that can be explored with the client...
P2S67: ... would be the development of self-instructional packages for at least part of the training.

This participant exhibited the most economical approach to design, in terms of the organization and control of the process. It was evident that the requirements of the task did not significantly alter the problem-solving strategy. Essentially the process sought answers to general questions related to the instructional goals, the skills, the learner and the resources. It was recommended that consideration of content be postponed until development.

P2S132: Then you'd kind of go through all this content stuff that is in there ...
P2S133: ... and your main problem would be, first of all, sequencing.
P2S134: Is there any sequencing?
P2S135: Some of it may be that B ought to follow A...
P2S136: ... but some of it may not make any difference.
P2S137: You'd probably want the self-instructional package to be one that the student could keep...
P2S138: ... and refer to if they forgot something.

Like Participant One, specific information about constraints triggered ideas for a solution very early in the process. But unlike Participant One, this participant had already acquired enough information about the problem to allow an immediate shift in the process. The reasons for this shift are not clear, but may be related to the fact that because the process was organized hierarchically, the goals were well established and did not need to be elaborated further, so decisions were made immediately (Jungermann, von Ulardt, & Hausmann, 1983).

P2S105: So I would say self-instruction would be very good for something like this, ...
P2S106: ... and has a lot of advantages ...
P2S107: ... and I would probably explore it with the client ...
P2S108: ... what they thought about this.

E: Let's assume the client thinks it's a good idea.

P2S127: OK, now we need to look at time for training, ...
P2S128: ... but we've sort of dodged that issue by the self-instructional thing. (Reads Card #24)
P2S129: "quickly", fine...
P2S131: ... then you'd set a deadline and say that you have to come in to be examined in 3 days.

The Design Process of Participant Three

The session of Participant Three closely resembled one that might be found with an actual client. The participant interacted with the experimenter by asking numerous clarifying questions. The process was similar to the second participant's in that systematic examination of information from various categories was undertaken. The difference was in the extent to which the information was considered and the amount of reconsideration of information that occurred during the process (See Appendix H).

Participant Three began by questioning the need for training. This episode set the stage for the subsequent analysis of the problem, placing some bounds on the problem space and clarifying the goals of the problem.

P3S1: And the objective again is we're teaching shelving and sorting?
E: Yes.
P3S2: Who's doing the work?
P3S3: Are they students?
P3S4: Is that on here?
E: Number 8 would give you that information.
P3S5: These don't already exist?
P3S6: Is this existing staff?
E: No.
(Reads Card #8)
P3S7: Who's doing the work now?
E: The current staff is doing the work now.
P3S8: What is the reason for adding more people, if the work is being done now?
E: They're overworked.
P3S9: Is the ... How do you know that adding more people to do shelving will relieve that problem and not put in a new problem of more supervision?
E: Good question.
P3S10: Is the problem overwork or is the problem books are piling up because they're not shelved?
E: They have so many other duties that they're not able to get to the

shelving.
P3S11: OK ... (Pause)
P3S12: All right, now we're trying to teach them how to do it.

After establishing the need for the training program, the participant examined information pertaining to skills, constraints and resources, always asking questions to clarify and elaborate on the information presented on the cards.

P3S17: (Pause) ... Work skills is Number 26, what's it say?
P3S18 (Reads card # 26) OK ... this is a kind of performance list.
E: That's where we need to concentrate.
P3S19: OK, fine. Let's look at time for training
(Reads card #24)
E: The way we envision this is bringing in the people maybe one day before school starts and give them some job orientation and practice.
P3S20: So what you're ... that assumes there's high turnover ... you're constantly training new people.
E: Probably once a year, maybe once a semester, we'll be adding new people.
P3S21: OK ... but they're students.
P3S22: This is a University library or a college library or high school?
E: Yes.
P3S23: All right ...
(Reads Index)
P3S24: The staff that have been doing the shelving, they were professional staff?
E: Yes.
P3S25: So they already knew this?
E: Yes.
P3S26: Essentially there is not an existing training program to be improved.
P3S27: This is from scratch?
E: Yes.
P3S28: What time is it now, what date? How many days out from the semester are we?
E: We have three months.

After five minutes, the participant paused to summarize the information that had been considered. This activity resulted in a concise organization of the information deemed pertinent, which was also recorded on the written notes.

P3S37: OK ... Let me make a few notes as we go through this.
(Takes paper and pencil)
P3S38: (Pause) What I'm doing here is writing down how much money you've got ...
(Writes notes)
P3S39: ...Staff available for one day of training ...

(Writes notes)
P3S40: ...Retrain/New train periodically ...
(Writes notes)
P3S41: What else did I ask you about?
P3S42: Uh, currently done by staff ...
P3S43: ...No existing training program ...
(Writes notes)
P3S44: (Looks at card #26) Skill list exists ...

The participant then continued to question the development and verification of the skills list (Card #26), and reconsidered the information about the learners, concluding that the skills would take time to develop.

P3S45: How did that skill list get developed?
E: Kind of through brainstorming by the staff, thinking about what it is they do.
P3S46: Has this been verified?
E: Not formally.
(Writes on notes)
(Reads card #26)
P3S47: Are we looking at employees who will be just a few hours/week, or are we looking at full-time people?
P3S48: Is that here?
E: Uh ...
P3S49: You know what I mean?
E: Yes, we're looking at 20 hours per week.
P3S50: (Writes on paper) OK, the reason I wanted to know that is ...
P3S51: Some of these things ... "Give accurate directions to all areas in the library".
P3S52: My view of that will be those things will have to develop and mature, and will not be as well done by 5 hour per week people.

After another reference to the written notes, the participant proceeded with the verbal description of the solution.

Unlike the other participants, there was no indication that any particular item of information triggered a definite solution. But the solution proposed was very similar to the solutions of the other participants. What could be seen in the protocols was a regularity to the process, similar to Participants Two and Four. The organization of the process followed a logical, systematic sequence in considering information from the various categories. The general design strategy was apparent in the way that the problem was approached (beginning with needs analysis), the way the goals were established and

elaborated (the persistent questions asked) and the way information was considered (systematically by category). The participant apparently possessed a general procedure for establishing the problem space. Problem information and prior knowledge combined to modify the problem space, and the participant controlled this process through questioning and reconsideration of information.

The Design Process of Participant Four

Participant Four verbally identified four phases of design which he used to help organize the task. After examining the participant's notes, it was discovered that these four phases, identified as column headings in the written notes, included needs, plans, development and evaluation/maintenance. Subsequent conversation with the participant revealed that these phases were related to the model that was utilized by the firm where he was employed. The participant did not proceed sequentially through these phases, but "bounced around" from one area to another (See Appendix I).

The session began by clarifying the goal of the training program, and the competencies required. Like Participant Three, questions were asked of the experimenter in order to elaborate on the information contained in the problem statement.

P4S1:	I'm going to focus on sorting and shelving, the first question is...
P4S2:	...where does my unit fit in the overall training program?
E:	It will be one portion of a one or two-day workshop conducted just before school starts. They will also be learning other library procedures during that time.
P4S3:	After 2 days of training, what do you finally expect, what level of competency?
E:	To know the basics, but probably still need some practice.

After examining the information about work skills, a tentative plan for evaluation was immediately developed. Similar types of activities occurred during the sessions of Participants One and Two, although the information being considered and the resulting decisions were different in all three situations. Encountering specific problem information

caused a decision to be made regarding a particular aspect of the problem solution.

P4S14: I'm going to develop an evaluation, one at the end of the workshop.
P4S15: How often do they work?
E: 20 hours per week.
P4S16: Halfway through the semester we need some kind of follow-up...
P4S17: ... I'll call on some of these staff people.
(Reads Card #10 - Involvement of Staff in Training)
P4S18: I'd like to ask them to revisit this environment...
P4S19: ... and tell them up front...
P4S20: ...they'll be evaluated again...
P4S21: ...probably not stringently...
P4S22: ...moreso to make some decisions about development for new staff...
P4S23: ... or if nothing else, what should be included in the next workshop.
E: That shouldn't be a problem. The librarians are working with these people all the time.

The participant confessed to a lack of knowledge concerning library procedures, expressing the desire to consult with a subject matter expert in order to verify competency levels. The other participants had also mentioned such consultations for the purposes of developing content and verifying steps in the sorting and shelving tasks.

(Reads Card #1- Book Classification Scheme)
P4S24: At this point I'm going to sew up the needs analysis.
P4S25: It's pretty clear and straight forward...
P4S26: ...there's no need to linger on it.
P4S27: At this point I would like to call in someone from the staff...
P4S28: ... and ask to what levels would we like these competencies.
P4S29: Only so that we can measure and make some decisions about it.

Information about the current library procedures triggered the possibility of refining and elaborating on the training goals. The participant identified what he considered to be a need, and questioned the experimenter regarding the possibility of developing training to address the need.

P4S30: In the past, have you had that kind of success rate?
E: No, even the librarians make mistakes. So when there's time, we tend to go back and look and sort shelves. That's a standard thing that's done.
P4S31: Is that efficient?
E: Probably not.
P4S32: Would you like to have some more efficient way of doing that?

E: Not as a part of this training project.
P4S33: There's something I would strongly recommend,...
P4S34: ... as a report that comes out of the evaluation...
P4S35: ... is that you look at some ways to self-check the shelving.

During what the participant identified as the planning phase, information about evaluation procedures, work assignments, work duties and the learners was selected. In considering the learners, the participant expressed the desire to examine an existing model so that the training program could be based on other, similar programs that might be in place at the college.

P4S40: When was the last time you did training on this, or is it the first time?
E: This is the first time.
P4S41: Do you have anything from staff that indicates how it's done?
E: There have never been any work-study employees before this. (Reads Card #25 - Work Assignments)
P4S42: So, you've indicated that none of these people have worked in the library before, but you've never had this situation?
E: No.
P4S43: Have you worked in areas where you've used work-study?
E: They have mainly been used for clerical duties, policing grounds, etc.
P4S44: I'm not sure whether right now...
P4S45: ...I want to discuss this or include it in the training...
P4S46: ... but it's important to know how these new employees will be perceived by the current staff and by the users.

The participant also described an established procedure, based on a team approach, that he wished to employ for this task. The procedure involved the generation of alternatives for instructional strategies, materials, and so forth. As will be discussed later, the emphasis on a team approach also influenced the characteristics of his proposed solution.

P4S60: So I was thinking about, in the actual plan,...
P4S61: ... I want to consider some developmental issues,...
P4S62: ...even though I won't actually begin to develop the course.

P4S72: It would take more time to do that...
P4S73: ... but I would develop some alternatives based on time, budget, experience of staff and the candidates, specific duties.
P4S74: What duties would the staff really need to be more practiced than others,...
P4S75: ... and really start to kind of fit it in.

P4S76: And maybe even have different members of the team go away...
P4S77: ... and then come back and present these alternatives...
P4S78: ... to get some kind of variety.
P4S79: And from there we would select one to be developed by consensus.
P4S80: And that one to be developed may be modified based on some of the other alternatives.

Participant Four, like the other participants, categorized the information available according to the process of sorting and shelving. As mentioned earlier, he also expressed the desire to consult with a subject matter expert in order to verify his ideas.

P4S81: I've identified some process or task things...
P4S82: ... what happens if you have multiple copies, oversized books.
P4S83: What I'm going to do is ask people who know about sorting and shelving the kinds of decisions that are made.

Participant Four, like Participants Two and Three, considered the problem information in a systematic way by selecting information that related to specific categories, in particular the categories of skills, learner and resources. His reluctance to make concrete suggestions regarding a solution may have stemmed from his experience in a team-based approach to instructional design. Also, he stated several times that his knowledge of library procedures was limited, and that he would prefer to consult with a subject matter expert before developing a solution. It may also be possible that the participant was still operating at a higher level of plan abstraction, and was not yet ready to consider specific details of the plan (Hayes-Roth & Hayes-Roth, 1979).

The Solutions

The proposed solutions given by all participants, while limited by the nature of the task to being consultative suggestions rather than fully developed instructional packages, were remarkably similar (See Table 22). Constrained by the available budget and resources, all solutions proposed extensive "hands-on" practice in sorting and shelving, an inexpensive instructional package that could be retained by the students for later reference, and reliance on "traditional" media such as overheads, line-drawings and paper and pencil evaluations. Two participants recommended a mostly lecture format for presentation of

content, while Participant Two suggested a self-instructional package to be completed by individual trainees. Participant One recommended pretesting trainees to assess their knowledge of the library system, while the other participants assumed that trainees who already possessed this knowledge would be hired.

Table 22.

Solution characteristics for each participant.

Participant	Characteristics
One	Lecture, handbook and hands-on practice
Two	Self-instruction with hands-on practice
Three	Lecture, handbook and hands-on practice
Four	Description of development activities

Participant One explained that the details of the solution would be worked out in a "brainstorming" session with the client. The solution suggested was lecture-based, with extensive "hands-on" practice after the content had been presented. It was also assumed that knowledge of the work environment, such as locations of books and journals, would be taught "least and last" because these skills would be developed on the job. As an evaluation technique, Participant One suggested "shadowing" the trainees for the first few days of work to assure that books were being shelved in the correct locations.

P1S134: I'm thinking now mostly lecture or presentation,...
P1S135: ... annotated notes,...
P1S136: ... maybe a little guidebook for kids to study.
P1S137: The main thing that made that decision was budget,...
P1S138: ... because it's a one-to-many situation.
P1S139: The cheapest thing possible is to put one person in front of a group...
P1S140: ... and use lecture and discussion and interaction.

P1S172: The next thing that occurs to me is you've got three things going on here.

P1S173: You've got the content...

P1S179: So at the beginning, the first you do is check out their knowledge...
P1S180: ... do they know these things?
P1S181: So we would cover that first...
P1S182: ...maybe with a questionnaire...
P1S183: ... take a little test and self-grade them.

P1S189: That's the first step, is to make sure they have those concepts.
P1S190: Then, you've got to spend a lot of time on process and environment.
P1S191: I would leave environment until last.
P1S192: This is what I would propose first:
P1S193: Once they understood, I'm making some assumptions, too...
P1S194: ...that they've used the library...
P1S195: ... and know something about the library.

P1S200: Those books got on the shelf somehow...
P1S201: ...how they gonna do that?
P1S202: We're going to teach you that.
P1S203: Here are the things you've got to know to put a book on a shelf...
P1S204: ... and to sort books.

P1S206: So you put your objective out there...
P1S207: ... the first step is you've got to know these things.
P1S208: The second step is going to be: this is how we do it.

P1S216: Whatever the process is that my library person tells me to go through.
P1S217: So we cover that next, in some way...
P1S218: ... and there's some exercises we could develop.

P1S228: But the environment and stuff...
P1S229: ... I would touch on that least and last.
P1S230: Because it's really going to be on-the-job training.
P1S231: I would say 'here's how we work around here'...
P1S232: ...'here's your guideline'...
P1S233: ...'these are the rules and policies written down here'...
P1S234: ... 'here's your supervisor'.

The solution proposed by Participant Two, a self-instructional package, was to serve two purposes: motivation and communication of objectives. Since the time for training was constrained, the designer suggested a deadline be placed on the time given trainees to complete the requirements. The participant preferred to postpone specific decisions about content, vocabulary and sequencing until a subject matter expert could be consulted.

P2S109: OK, then the next thing you'd do is sit down with the client and work through the introductory exercise ...
P2S110: ... what's going to be done live.

P2S111: It's going to have two purposes: ...
P2S112 ... one is motivation ...
P2S113: ... to persuade them to take this seriously ...
P2S114: ... really work through self-instructional materials, ...
P2S115: ... evaluate themselves honestly.

P2S118: The second thing would be to set before them, ...
P2S119: ... in terms everybody could understand, ...
P2S120: ... the purpose of the training program: ...
P2S121: ... these are the things you're going to be expected to do.

P2S136: You'd probably want the self-instructional package to be one that the student could keep...
P2S137: ... and refer to if they forgot something.

P2S151: Then vocabulary.
P2S152: How are you going to say this?
P2S153: And third, do you need anything but words?
P2S154: Here is where you turn to your knowledge of learning resources ...
P2S155: ... and you say, maybe you need some pictures ...
P2S156: ... or a graphic ...
P2S157: ... you need to refer them to the real thing.
P2S158 Now in looking at this project, it looks like a good bit of the self-instructional package should refer them to the real objects.

P2S165: ... so that in this case you wouldn't need much in the way of AV.

Participant Three approached the solution from a managerial perspective, designating tasks that would be "handed-off" to other designers. These included "shadowing" a librarian to verify the skill list, developing objectives based on the verified list, and developing evaluation procedures from the objectives.

P3S65: OK ... we're three months out .
(Pause)
P3S66: Probably what I would first suggest we do is send the developer to the library and shadow someone for three days ... two days.
P3S67: We need to validate, or to verify, that these (points to card #26) in fact are what people need to know.
P3S68: We're also, and I don't know if this is on there ...
P3S69: We're going to be looking for assumptions made by trained staff ...
P3S70: ... in other words we're looking for gaps ...
P3S71: ... what has been overlooked.

Participant Three also suggested "hands-on" training with coaching that would be diminished over time. The content would be developed through consultation with the subject matter expert, and the materials would contain no "fancy AV stuff". The participant

also suggested a formative evaluation just prior to delivery time and a long-term evaluation at the end of the academic year. No specific suggestions were given for the focus or procedures of this evaluation. Since this participant managed an instructional design "shop", it is possible that the details of the solution had been used as standard procedure in other projects. This is particularly evident in the focus on time lines and approval points.

P3S109: So really, what I said there a few minutes ago, ah, perhaps one of the things I should ask now is ...
P3S110: ... since we're 90 days out, a couple of issues.
P3S111: As a client, how much time would you have available to help develop the training?
P3S112: What split do you want between ...
P3S113: In this contract, do you want us to give you the package, and you only approve it, ...
P3S114: ... or do you want to be involved in the development?
E: We would like to be involved to the extent that we review what you have done. We don't really have the time to actually develop it ourselves. We could certainly serve as resources.
P3S115: OK. Then what I probably want you to do is assign one person to us as a content expert.
P3S116: Essentially a subject matter person who can speak for the group at the library ...
P3S117: ... and who has authority to make a final decision.
P3S118: We would, if we have agreement on that, probably set up some set of time-line dates, saying that the initial design will be about here ... approval point.
P3S119: Another approval point where, if there are any materials for tests or the general work plan of the training be laid out.
P3S120: That's a sign-off point.
P3S121: We would also likely, like a week or ten days before school starts, ...
P3S122: ... or perhaps even in summer school before the end of summer, ...
P3S123: ... we would like to take someone off the street and run them through, with you teaching it, ...
P3S124: ... so we can assess, whoever's going to be the teacher, ...
P3S125: ... assess whether they understand what it is and ...
P3S126: ... whether anybody ...
P3S127: ... whether this person can learn it.
P3S128: We'll probably have to make some revisions then, not the least of which could be for revising the flow of the information.

P3S134: This implies that in the development phase we will need you, as a content expert, to validate our assumptions.
E: We can do that.
P3S135: OK.
P3S136: In terms of the budget, I don't see that you're going to have a lot of cost, out-of-pocket cost.

P3S137: My guess is that ... (Pause)
P3S138: I don't really see a lot of necessity for very fancy A-V stuff here.
P3S139: Probably more like something that's text with line drawings, line art...
P3S140: ... and breaks it down into just a few steps per thing to do ...
P3S141: ... and easily indexed.
P3S142: Maybe develop a job aid, a reference thing that they can pull out and look it up.
P3S143: It's unrealistic to assume early on that they can carry all that in their heads, even if they're half-time.
P3S144: (Pause) I'd probably also tell you as a client that, and I think you would agree, that we'll need to do some evaluation with this ...
P3S145: ... certainly at the end of a term, before you do this again, ...
P3S146: ... we'll want the workers, the students, to have input as to what's good and what's bad, and ways it can be improved.
P3S147: It's also quite conceivable that we would send the developer back and shadow some of the new employees as they work, to see how the stuff gets used.

The solution described by Participant Four differed from those proposed by the other participants. As mentioned earlier, Participant Four preferred to postpone more specific development decisions until he had consulted with a subject matter expert. As a result, the solution consisted of a description of further activities he would pursue in developing the instructional product, rather than a discussion of the specific characteristics of the product. Some of the characteristics of the solution which emerged early in the process have already been discussed (the proposed evaluation procedure). Specific activities that would eventually produce a solution were mentioned later in the session, including a survey of the learners, generation of alternatives by team members, media selection and teaching strategies.

P4S48: Normally in the plan I go ahead and stick in my alternatives as I come up with a plan...
P4S49: ... I'm considering the development...
P4S51: Right now I need to make some preliminary decisions about development...
P4S52: ... the strategies...
P4S53: ... the aids that the person would have...
P4S54: ... the time on task...
P4S55: ... the previous experience of the prospective employees in the area.
P4S56: Assuming that they're coming to a workshop environment...
P4S57: ... besides the job application form,...
P4S58: ... maybe a survey about how they feel about this job,...

P4S59: ... or other jobs they've been in.

P4S63: I'm thinking about the workshop...
P4S64: ...what's the media that's going to be used?
P4S65: What form is it going to take... the actual agenda?
P4S66: Who says what, when?
P4S67: How do we introduce the topic?
P4S68: Any kinds of practice or practical applications during the thing?
P4S69: In considering that, I'm saying "what kinds of alternatives can we come up with".
P4S70: Even now, focusing on how long we want this thing to be,...
P4S71: ... and what kind of things we can fit in and begin to maneuver.

P4S91: As I develop it, I don't know...
P4S92: ... a film, cards, examples, testimonials...
P4S93: ... I'm not sure yet.
P4S94: But during the development I'm going to make the actual decisions.
P4S95: And when I finish I'm going to have a package, an agenda for the session, an instructors manual with the materials.
P4S98: At this point we've got a product we want to test.
P4S99: According to the time and budget available...
P4S100: ... it will need to be reviewed.
P4S101: The project or team leader, or the client, will do the review and make recommendations based on their experience.

P4S107: In the evaluation stage, we're asking "does this product meet expectations", period.
P4S108: I would call in an evaluation specialist ...
P4S109: ... because I don't know anything about that.
P4S110: A field test might not be practical because of the time and setting...
P4S111: ... the staff is so busy.
P4S112: I would, however, create prototypes...
P4S113: ...and grab someone...
P4S114: ... and have them do some of this...
P4S115: ... a formative approach.
P4S116: After your workshop, you'll get some feedback that can be used for maintenance of the product.

Summary of the Results

The results of this study suggest that, at least for the task investigated, certain categories of information are more critical than others for the problem formulation, goal elaboration and decision making of instructional designers. For the task undertaken in this study, the categories of information which received the most attention were resources, budget, learner and skills. Information about content and the task to be trained was not accessed for the most part, perhaps because the participants possessed sufficient prior

knowledge which allowed them to concentrate on the other categories. But it is also possible that detailed information about content and tasks is not necessary until later in the process. The latter explanation seems likely, since all participants expressed the desire to consult with a subject matter expert during the development phase.

The dispersion of information accessed over time indicates that the participants followed a systematic strategy for acquiring information, and that these strategies were similar for Participants Two, Three and Four. This may be due to the fact that design is a schema-driven activity, and that the schema controls the problem structuring phase of the design process, as suggested by previous research (Jeffries, Turner, Polson & Atwood, 1979; McCallin, 1986; Nelson, 1987). The results of this study cannot confirm this assertion, however, since no attempt to describe the participant's design schema was made.

Even though the design processes of the participants appear dissimilar on the surface, certain similarities were revealed through the qualitative analyses of the processes (See Table 23). Most striking is the influence that practical constraints of budget and resources had on both the processes and the solutions. In all cases, consideration of this information caused a reconfiguration of the problem space (Sherman, 1978). When Participant Two encountered the information about these constraints, the process was halted and a solution was immediately presented. Likewise, Participant One suggested a possible solution after selecting this information, but examined other information in search of alternatives. When none were found, the participant settled on a solution that was largely influenced by practical constraints. It is interesting to speculate how the process and the solutions might differ if an unlimited budget were available. As noted by Newell and Simon (1972), problem constraints influence the construction of the problem space, and in the case of the task presented in this experiment, these constraints may have eliminated many of the possible solution alternatives. In fact, Participant One noted that "if we had more money we might consider some kind of computer-based system."

Table 23.

Process characteristics for each participant.

Participant	Characteristics
One	Sequential access of information, classification into categories
Two	Systematic access by categories, focusing on learner, skills and constraints
Three	Systematic access by categories, focusing on needs, learner, skills and management issues
Four	Systematic access by categories, focusing on needs, learner and skills

The qualitative analyses reveal other similarities between the processes utilized by the participants. The participants all imposed some type of structure on the problem information. Participants One, Two and Four verbalized the categories they used to organize the information, while the categories employed by Participant Three were not specifically stated. Nevertheless, it can be seen from the quantitative analysis that Participant Three tended to focus on specific categories which corresponded to the other participants. The process of establishing some kind of structure for problem information has also been shown in studies of other types of design (Akin, Chen, Dave & Pithavadian, 1986; Carroll & Thomas, 1979; Eastman, 1972).

Conclusions

By viewing and studying the instructional design process from the perspectives of human problem solving, planning and decision making research, a better description of the nature of instructional design expertise may be generated. This study represents a preliminary attempt to provide information that may result in greater understanding of the complex process of instructional design. While the groundwork for further investigations in this largely unknown area has been laid, and similarities between the problem-solving activities of instructional designers and designers from other domains have been suggested, considerable work still remains.

The study of instructional design from the perspective of problem-solving research seems appropriate, given the results of this study. Many of the processes identified by researchers in other areas were also observed in this experiment. Specifically, the limitations of human memory impact on the design process in many ways, particularly in the designer's need to periodically summarize information that had been previously acquired, to use external memory sources such as written notes, and in some cases, to select information that had already been accessed. Participants also tended to decompose the problem, and work on each sub-problem separately.

The effect of prior experience on the design process is apparent in the results of this study. Information stored in long-term memory in the form of schemata relating to various aspects of the design process influenced the ways in which the designers proceeded with the task. In many instances, participants identified patterns of problem information and proposed tentative solutions based on "rules" or productions that were stored in long-term memory. In several other instances, the decision-making strategies were similar to the diagnostic model found in medical research, where a quick conclusion was made based on particular problem information, and then the conclusion was tested in subsequent episodes in order to confirm or deny the decision. It can be assumed that these strategies and

productions develop through experience with the instructional design process.

The particular design "style" of each participant may also have influenced the decisions made and the flow of the process. Some participants chose to ask many questions, as if they were interviewing a client. In other cases, comments such as "what I like to do in this situation" revealed that a particular solution was chosen based on personal preferences. In addition, the participant with a management background tended to focus on details of a contract, while the participant with experience in working in a design team expressed the desire to consult with others before developing a solution.

The solutions proposed by the participants were very similar in many cases. This may be due to the fact that the major constraint, the budget limitation, forced the design process into a particular path in which few alternatives were available. The participants came to the same conclusions, but by different methods. Since the "practical" considerations of budget and resources dominated the decision-making process, it would be interesting to see how varying the practical constraints of the problem might affect the decisions made during the instructional design process.

As is often the case, the results of this study have answered some questions while generating new questions. The central problem in interpreting the results of this experiment revolves around one question. Can the task undertaken by the participants be considered as design? Given the results, this question cannot be clearly answered. The experimental task contained many of the features of design, and many of the behaviors identified in this study have also been identified by researchers in other areas of design investigations. But since the participants in this study did not actually develop a solution, many other design activities may have gone unobserved in this experiment. Further research is necessary to determine how designers might proceed through the development and evaluation of an instructional product.

The methodology employed was limited in the ability to trace the instructional design

process. Even though objective and quantitative means for analyzing the data were employed, some extensions to the methodology are suggested. It was not possible to determine with precision how the participants' prior knowledge was being utilized. It was surmised that the participants' inattention to the training task and content categories implied that prior knowledge was being substituted for information from the design task environment. But as noted previously, this information may not be necessary for the initial phase of instructional design. Perhaps varying the content area of the design task, such as requiring the design of training for fighter pilots instead of training for librarians, might produce different results. There may be a range of ill-definedness for design problems which could be a function of both the information available and the experience which the designer brings to the task.

The methodology is also limited in that the dynamics of interpersonal communication are removed. This fact was noted and planned for in this study in order to maintain some control over the many variables operating in the design situation. But future research should build on this study by examining the changes in the design process that would occur in a session where the designer interacts with a live client. It may be that the "balloon-drawing" approach taken by Participant One is effective in such situations, and if so, we need to better understand the dynamics of participatory design. Situations where designers work in teams are also related to these ideas, and should also be investigated.

As can be seen, the implications of this research are both wide-ranging and restricted. Given only the findings presented here, it would be difficult to suggest any definitive changes that should be made in either the process as it is practiced or as it is taught. But more research in this area could provide a clearer picture of the process than is now available. In particular, it is important to examine how expertise with the design process develops. Such research would also benefit the current work being done in the development of expert systems for instructional design applications. But most importantly,

it is necessary to pursue further research in this area so that more definitive descriptions of the instructional design process can be developed.

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Appendix A

Consent Form

This research project involves:

1. An interview focusing on your perceptions of the instructional design process.
2. Preliminary design of a training program.

Completion of the project should take about 2 hours.

We hope to learn more about the instructional design process through this project. Your participation will be confidential, and you are free to withdraw from this project at any time without penalty or prejudice.

If you have further questions, call Wayne Nelson (5587, 400 Gym) or Dr. John Burton (5587, 400 Gym).

I hereby agree to voluntarily participate in the research project described above and under the conditions described above.

_____

Signature

Thank you for participating.

Appendix B

Contents of Problem Information Cards

from Various Categories

Card Number	Card Label	Information
		Category One: Task
18	SHELVING CUTTER NUMBERS	The cutter numbers are shelved alphabetically by letter, and then according to numeric order (the numbers are decimals, not whole numbers).
19	SHELVING DIFFERENT EDITIONS	Books are shelved in ascending order of edition numbers, with older editions on the left and newer editions on the right.
20	SHELVING MULTIPLE COPIES	Multiple copies are shelved in numeric order from smallest to largest.
21	SHELVING OVERSIZED BOOKS	Oversized books are shelved in order of call numbers on special shelves against the wall near the exit.
22	SHELVING REFERENCE BOOKS	Reference books are shelved in order of call numbers on the special shelves on the first floor.
23	SHELVING RESERVE BOOKS	Books and other materials of limited circulation are shelved behind the Loan desk in order of the call numbers.
		Category Two: Content
1	BOOK CLASSIFICATION SCHEME	Books are classified according to categories of knowledge as indicated by the letters of the alphabet.
9	FIRST LINE OF CALL NUMBER	Cards and books are organized alphabetically by the first letter on the top line of the call number.

Appendix B, continued

Card Number	Card Label	Information
		Category Two: Content, continued
17	SECOND LINE OF CALL NUMBER	The second line of call numbers are put in numerical order from smallest to largest.
4	CUTTER NUMBERS	The third (or fourth) line of the call number is the cutter number.
6	EDITIONS OF THE SAME BOOK	The last line of a call number indicates the date the edition was released. These are only used when the library owns more than one edition of the same book.
12	MULTIPLE COPIES	Several copies of the same book may be found in the library. These copies are indicated by a lowercase "c" followed by a number in the last line of the call number.
13	OVERSIZED BOOKS	Oversized books are indicated by a small letter "q" in the first line of the call number.
15	REFERENCE BOOKS	Reference books are indicated by the "Ref." notation in the first line of the call number.
16	RESERVE BOOKS	Books and other materials of limited circulation are indicated by a "X" in the first line of the call number.
		Category Three: Skills
7	EMPLOYEE EVALUATIONS	Student assistants are evaluated at the end of each semester on those qualities considered essential in good workers. This evaluation will become part of the student's permanent record, and will be used as reference material for prospective employers.

Appendix B, continued

Card Number	Card Label	Information
		Category Three: Skills
26	WORK SKILLS	All workers should be able to: -Check books in or out -Check reserve materials in or out -Check current periodicals in or out -Sort and shelve books -Count, record, and file circulation cards -Check out keys to Photo Lab -Check in and rack newspapers -Empty bookdrop -Shelve bound and unbound magazines -Pull canceled cards from catalog -Give accurate directions to all areas of the library -Assist patrons in the use of the card catalog
5	DAILY WORK DUTIES	All employees must perform the following duties: -Empty book drop (At 8 AM, 9 AM, 12 noon, and 4:30 PM, unless it's very busy) -Check in books from book drop* -File books in order on sorting shelves* -Shelve books from sorting shelves and on trucks -Straighten up reading room -Shelve bound and unbound magazines -Straighten bound volume shelves and unbound issue stacks -Shelve reference books -Put college catalogs in order -Put public affairs pamphlets in order -Put newspapers in proper stacks on shelves * Can be done when only one person is working. Everything else should be done when more than one person is working.
		Category Four: Learner
8	EXPERIENCE OF PROSPECTIVE EMPLOYEES	Although it is likely that prospective employees have used a library before, none have worked as an employee in a library.

Appendix B, continued

Card Number	Card Label	Information
		Category Five: Setting
3	THE COLLEGE	The college is a small liberal arts college located in western Pennsylvania. Its enrollment averages about 1000, with 200 seniors, 200 juniors, 200 sophomores and 400 freshmen.
14	PATTERNS OF LIBRARY USE	Typically, the library is busiest in the evenings during the week. Most students use the facility as a study area, and there are often problems with excessive noise. Faculty use the library infrequently, since the emphasis is on teaching, and not research. Some community members patronize the library, but not very extensively. Freshmen English classes often meet in the library at the beginning of the semester for tours and instruction in research.
		Category Six: Time
24	TIME FOR TRAINING	It is necessary to train employees as quickly as possible since their help is needed for library operations at the beginning of each semester.
		Category Seven: Resources
10	INVOLVEMENT OF STAFF IN TRAINING	A minimum of staff involvement in training employees is necessary since staff members must also perform many other duties.
25	WORK ASSIGNMENTS	After check-in, supervisor will give work assignments for the day.
		Category Eight: Budget
2	BUDGET FOR TRAINING MATERIALS	A limited amount of funds is available for training materials, somewhere in the range of $300-$500.
11	LIBRARY STAFF BUDGET	The library typically works with a limited budget for staffing. This year, approximately $40,000 has been budgeted for student staff, based on 20 hours per week for each of ten employees.

Appendix C

Information Card Index

1. Book Classification Scheme
2. Budget for Training Materials
3. The College
4. Cutter Numbers
5. Daily Work Duties
6. Editions of the Same Book
7. Employee Evaluations
8. Experience of Prospective Employees
9. First Line of Call Number
10. Involvement of Staff in Training
11. Library Staff Budget
12. Multiple Copies
13. Oversized Books
14. Patterns of Library Use
15. Reference Books
16. Reserve Books
17. Second Line of Call Number
18. Shelving Cutter Numbers
19. Shelving Different Editions
20. Shelving Multiple Copies
21. Shelving Oversized Books
22. Shelving Reference Books
23. Shelving Reserve Books
24. Time for Training
25. Work Assignments
26. Work Skills

Appendix D

Background and Experience Questions

1. How many years of experience do you have in the instructional design field?
2. How many instructional design projects have you worked on in the past year?
3. What is your area of concentration within the instructional design field?
4. How many years of related experience have you had?
5. What is the nature of this related experience?
6. Have you published any articles relating to the field of instructional design?
7. How many years have you taught, and at what levels?

Appendix E

Instructions to the Participant

The cards in this box contain information collected from a client during an interview. The information pertains to a training program for library personnel. Your task is to use this information to design the portion of the training program which concentrates on sorting and shelving books.

The information collected in the interview has been printed on index cards. Each card contains a label describing the information on one side of the card, with the actual information on the other side. An index of the card labels, arranged alphabetically, is also available. The cards are arranged in the box in the same order as this index. If the information is necessary for the decision that you are considering, remove the card from the box. You may ask the experimenter questions as you proceed with the task. We would like you to think aloud as you complete the task. Please verbalize all of your thoughts as best you can. If you have any questions before you begin, please ask the experimenter.

Appendix F

Design Protocol of Participant One

Behavior	Utterance
READ(problem statement)	
GOAL(problem structure)	"I'm going to figure out what all these mean."
READ(#1) CLASSIFY(#1)	"Now I know we're teaching Library of Congress."
READ(#2) CLASSIFY(#2)	"We're not going downtown on this one, are we?"
READ(index) SUBGOAL(audience) READ(instructions) READ(#3) CLASSIFY(#3)	"Who's my audience on this?" "I'm going to skip the college for now. The college isn't my audience."
READ(#4) CLASSIFY(#4)	"That's a piece of content."
SUBGOAL(problem structure) WRITE(content)	"I'm going to separate stuff into what's content..."
SUBGOAL(problem structure) WRITE(process)	"...there's probably going to be some process stuff..."
SUBGOAL(problem structure)	"...there's going to be some demographics, logistics, environmental considerations."
SUBGOAL(organize)	"So now I'm grouping this stuff."
READ(#5) WRITE(process) WRITE(content)	
EXPLAIN(client interaction)	
READ(#6) CLASSIFY(#6)	"That's going to be content, I can just tell that."
READ(#7) CLASSIFY(#7) WRITE(evaluation)	"I'm not sure where to put it yet."
READ(#8) RECEIVE(employees) CLASSIFY(#8)	"What do they come in with?"

Appendix F, continued

Behavior	Utterance
EXPLAIN(prerequisites)	
READ(#9 label) CLASSIFY(#9)	"First line of call number, that's content."
READ(#10) CLASSIFY(#10) WRITE(#10)	"They've got to do this as an overload. That's environmental."
READ(#11) ASK(number of employees) RECEIVE(8 per semester) SUBGOAL(size of program) CLASSIFY(employees) PLAN(solution)	"I need to get a feel for the size of the training program." "OK, so you figure the turnover is high." "I'm not going to do anything elaborate with $300. Probably something fairly simple, traditional, probably lecture."
READ (#12) CLASSIFY(#12)	"Oversized books, content."
READ(#14) CLASSIFY(#14)	"I don't know what to do with that."
READ(#15) CLASSIFY(#15)	"Reserve books, that's content."
READ(index) CLASSIFY(index)	There's my division between content and process."
READ(#24) RECEIVE(workshop format) CLASSIFY(workshop format)	"Orientation week, or whatever."
READ(#25) READ(#26)	
GOAL(summarize) WRITE(content) WRITE(process) CLASSIFY(#25, 26, 14)	"Now let me see what I just did." "These things define how and when you will do the process of shelving."
PLAN(budget constraints) PLAN(assess learners) PLAN(process instruction) PLAN(environment instruction) PLAN(evaluation)	"...mostly lecture/presentation." "The first thing you do is check out their knowledge." "You've got to spend a lot of time on process." "It's really going to be on-the-job training." "Someone's got to watch and see..."

Appendix G

Design Protocol of Participant Two

Behavior	Utterance
READ(problem statement)	
READ(index)	"I don't see any information here on the purpose."
CLASSIFY(index)	"...mostly it's content, what you want them to learn."
GOAL(purpose)	"First I want to know what you want to happen."
WRITE(purpose)	"...and what you want is sorting and shelving."
GOAL(subskills)	"Then we want to know subskills."
WRITE(subskill)	"...knowledge of the system."
CLASSIFY(index)	"Patterns of Library Use...that wouldn't be very important."
CLASSIFY(index)	"Different kinds of books, call numbers. That's going to be content."
READ(#26)	
CLASSIFY(#26)	"These are knowledge problems. There isn't anything they have to learn to manipulate, so the skills thing is really just knowing how to do things."
GOAL(attitudes)	"I want to know attitude formation desired."
READ(index)	
DECIDE(attitudes)	"You probably want to encourage operations, cheerfulness."
DECIDE(purpose)	"We've got a dual purpose."
WRITE(purpose)	"Prepare to do job and prepare to deal with customers."
GOAL(learner)	"Now I want to know what kinds of people are we asked to teach this to."
READ(#8)	
CLASSIFY(#8)	"We've got neophytes."
READ(index)	"Let's see if I can learn anything else."
DECIDE(learner)	"We're talking about a naive audience."
PLAN(learner)	"There may be some need to teach them vocabulary."
RULE(naive learner)	"If they had some experience in the library, you wouldn't need to bother with that."
GOAL(schedule)	"Next thing we want to know is the schedule..."
GOAL(resources)	"... and the resources available."
READ(#2)	
CLASSIFY(#2)	"$300-500 .. wouldn't be much if you're paying salaries."
DECIDE(resources)	"This is probably the cost of training personnel."

Appendix G, continued

Behavior	Utterance
READ(index)	"What else do we have?"
READ(#10)	
CLASSIFY(#10)	"I suppose that means you don't have a director of training."
ASK(resources)	"Who's doing the training?"
RECEIVE(workshop)	
DECIDE(self-instruction)	"I would explore the possibility of self-instruction."
EXPLAIN(self-instruction)	
RECEIVE(self-instruction viable)	
PLAN(materials)	"...sit down with the client and work through introductory exercises."
PLAN(materials)	"going to have two purposes: motivation and expectations."
READ(index)	
READ(#5)	
CLASSIFY(#5)	"'After check-in', that's something different."
GOAL(time)	"How long have I got, although we've dodged that by self-instruction."
READ(#24)	
CLASSIFY(#24)	"Quickly, OK."
RULE(time/self-instruction)	"...then you'd set a deadline and say they have to come in and be examined in three days."
PLAN(content)	"Then you'd go through this content stuff."
PLAN(sequencing)	"You could start with one and go to the end, but there might be groupings."
PLAN(vocabulary)	"How are you going to say this?"
PLAN(illustrations)	"Maybe you need some pictures, or a graphic."
PLAN(materials)	"The self-instruction should refer to the real objects."

Appendix H

Design Protocol of Participant Three

Behavior	Utterance
READ(problem statement)	
GOAL(understand need)	
ASK(employees)	"Who's doing the work, are they students?"
READ(#8)	
ASK(current employees)	"Who's doing the work now?"
RECEIVE(present staff)	
ASK(why more employees)	"What is the reason for adding more employees?"
RECEIVE(overwork)	
PLAN(hiring)	"We'll assume that you will hire them, and get people who have the right set of skills."
ASK(develop skills)	"Is it necessary for us to develop some kinds of skills?"
READ(#26)	
GOAL(time)	"Let's look at time for training."
RECEIVE(workshop)	
ASK(retraining)	"That assumes that you're constantly training new people?"
RECEIVE(employee turnover)	
ASK(setting)	"This is a university library?"
RECEIVE(yes)	
ASK(existing program)	"This is from scratch?"
RECEIVE(yes)	
ASK(development time)	"How many days out from the semester are we?"
RECEIVE(3 months)	
READ(#2)	
CLASSIFY(#2)	"There's not a lot of budget there."
READ(#10)	
CLASSIFY(#10)	"It would be difficult to stage a very extensive training session that would involve a teacher."
RECEIVE(staff as instructor)	
GOAL(summarize)	
WRITE(staff availability)	
WRITE(budget available)	
WRITE(retraining required)	
WRITE(current employees)	
WRITE(new program)	
WRITE(skill list exists)	

Appendix H, continued

Behavior	Utterance
ASK(development of skill list)	"How did the skill list get developed?"
RECEIVE(staff)	
ASK(verified)	"Has it been verified?"
RECEIVE(no)	
WRITE(skills not verified)	
READ(#26)	
ASK(full-time employees)	"Are we looking at full-time people?"
RECEIVE(20 hours/week)	
DECIDE(constraint)	"Some of these things will have to develop and mature."
READ(#24)	
CLASSIFY(#24)	"I already looked at that."
READ(#5)	
READ(index)	"I'm thinking about what I overlooked."
READ(#5)	
ASK(skill list)	"You said the skill list was brainstormed?"
RECEIVE(yes)	
ASK(work duties)	"How did the daily work duties get developed?"
RECEIVE(same method)	
ASK(who developed)	"Did one person develop these?"
RECEIVE(validated by staff)	
ASK(group consensus)	"There's a group consensus that this is right?"
RECEIVE(yes)	
PLAN(skill list)	"We need to validate that these points are what people need to know."
READ(notes)	
READ(#8)	
CLASSIFY(#8)	"We have people who understand what a library is and how its's organized, but have never had to think about the tasks involved in shelving and sorting."
PLAN(skill list)	"We need to develop a list of specific things we want people to learn."
PLAN(evaluation)	"We're going to develop how we're going to know that they do it."
PLAN(strategy)	"There should be some hands-on training."
PLAN(evaluation)	"...develop some sort of evaluation plan for the employees that gives them feedback."
CLASSIFY(content)	"The technical details of the content...look like sub-points within modules."
PLAN(content)	"I won't deal with that. I would delegate it."
READ(index)	
READ(#7)	

Appendix H, continued

Behavior	Utterance
ASK(evaluation process)	"Already existing is an evaluation process?"
RECEIVE(campus-wide)	
CLASSIFY(evaluation)	"That helps to credential people for further employment.. ...helps motivate them."
READ(index)	"I'm just going down this stuff to see what else in here I can look at."
ASK(development time)	"Do you want us to give you a package, or do you want to help develop the training?"
RECEIVE(consult/review)	
PLAN(content expert)	"I want you to assign one person as a content expert."
PLAN(time line)	"We'll have sign off points..."
PLAN(field test)	"Just before the semester we'll want to try it out."
PLAN(formative evaluation)	"We'll probably have to make some revisions...for revising the flow of information."
PLAN(budget)	"I don't see that you're going to have a lot of cost."
PLAN(materials)	"I don't really see a lot of necessity for fancy AV stuff here."
PLAN(materials)	"Maybe develop a job aid, a reference."
PLAN(summative evaluation)	"We need to do some evaluation, at the end of the term."
PLAN(summative evaluation)	"We might need to send the developer back and shadow some of the new employees."

Appendix I

Design Protocol of Participant Four

Behavior	Utterance
READ(problem statement)	
GOAL(expectations)	"I'm looking at expectations of whoever made the decision to have training."
ASK(organization of training)	"Where does this unit fit in the overall program?"
RECEIVE(workshop)	
WRITE(purpose)	
ASK(competency)	"What level of competency?"
RECEIVE(basic level)	
ASK(learner)	"What's the background of these people?"
READ(#8)	
GOAL(categorize information)	"Because it's in this form, I may begin to put some of this into the four design phases."
CLASSIFY(index)	
WRITE(index information)	
READ(#26)	
PLAN(evaluation)	"I'm going to develop an evaluation at the end of the workshop."
ASK(work hours)	"How often do they work?"
RECEIVE(20 hours/week)	
PLAN(summative evaluation)	"Halfway through the semester we need some kind of follow-up."
PLAN(evaluation procedure)	"I'll call on these staff people."
READ(#10)	
PLAN(evaluation procedure)	"I'd like to ask them to revisit this environment."
RECEIVE(acceptable plan)	
READ(#1)	
DECIDE(needs)	"I'm going to sew up the needs analysis."
PLAN(level of competency)	"I would like to call in someone from the staff and ask to what levels we would like these competencies."
RECEIVE(no mistakes)	
ASK(successful)	"Have you been that successful in the past."
RECEIVE(no)	
ASK(part of training)	"Would you like to have some more efficient way of doing it?"
RECEIVE(not now)	
DECIDE(self-checking)	"I would strongly recommend that you look at some

Appendix I, continued

Behavior	Utterance
	ways to self-check the shelving."
GOAL(begin planning)	"Based on these expectations, we can begin to plan."
READ(#7) READ(#8) CLASSIFY(#8)	"Employees are the best indicators of what needs to be done."
READ(index)	
ASK(train before)	"When was the last time you did training on this?"
RECEIVE(first time) ASK(other experiences)	"Do you have anything that indicates how it's done?"
RECEIVE(first time in library) READ(#25) ASK(work study)	"Have you worked in other areas where you've used work study?"
RECEIVE(yes) PLAN(perception of employees)	"It is important to know how these employees will be perceived by staff and users."
READ(#5) CLASSIFY(#5) WRITE(notes) READ(index)	
GOAL(preliminary development)	"Now I need to make some preliminary decisions about development,...even though I won't begin to actually develop the course."
PLAN(development process)	"Need to come up with some alternatives."
PLAN(generate alternatives)	"Have different team members go away and come back to present alternatives."
PLAN(subject matter expert)	"I'm going to ask people who know about sorting and shelving the kinds of decisions that are made."
PLAN(formative evaluation)	"The team leader or client will do the review and make recommendations based on their experience."
PLAN(field test)	"A field test would not be practical because of time and setting."
PLAN(formative evaluation)	"I would create prototypes and grab someone and have them do some of this."
PLAN(maintenance)	"After the workshop, you'll get some feedback that can be used for maintenance of the product."

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