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ABSTRACT

This study applied previously identified cognitive theory and research to the development of an instructional design model for teaching mental aspects underlying work and family activities in a context of rapid change and high technology. The model was tested by developing a prototype, materials required by the prototype were developed, and the design was tested for effectiveness in facilitating development of the mental aspects underlying activities within the selected domain. In the development of the model, four factors were identified as particularly significant in supporting learners' knowledge construction: fidelity of the learning situation to the real world, visualization, range and depth of learners' experiences, and mediation of learners' interpretations of their experiences. Knowledge constructed by learners was intended to: (1) integrate goals, intentions, and actions with features of the external world and domain-knowledge concepts and principles; (2) focus attention on deep-level features; (3) facilitate interpretations in terms of powerful, superordinate-level concepts and principles; and (4) support sensitivity to subtle but important variations among cases. A computer-based videodisc learning environment was developed as a prototype, and its intermediate level of instruction was tested. Findings supported the effectiveness of the learning environment in elaborating, modifying, and reorganizing knowledge structures in ways that enhance capacities to detect deep-level features and to apply knowledge in making judgments regarding actions that fit a situation. (51 references) (CML)

Minnesota Research and Development Center for Vocational Education

# Instructional Design for Facilitating Higher Order Thinking Volume II: Instructional Design Model



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# Instructional Design for Facilitating Higher Order Thinking

## Volume II: Instructional Design Model

by

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## ABSTRACT

Changes that are occurring in work and family life have implications for vocational education. The usefulness of job and task analysis is becoming more limited as rapid changes in workplace and family activities reduce the predictability of tasks and activities, and as mental processes that are not directly observable become more central in these tasks and activities. This study sought alternative approaches to vocational education curricular and instructional development by applying cognitive theory to the development of an instructional design model. Four factors were central in the instructional design model: (a) fidelity of the learning situation to the real world, (b) visualization, (c) range and depth in learners' experiences, and (d) mediation of learners' interpretations of their experiences. A computer-based, level III video-disc learning environment was designed as an instructional prototype based on this model. The intermediate level of the prototype was developed and tested in this project. Learning gains were found on all assessments used. Findings supported the effectiveness of the intermediate level learning environment in developing learners' knowledge and thinking relevant to work activities.

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# CHAPTER 1

## INTRODUCTION: PROBLEM, RATIONALE, AND PURPOSE

The research reported in this document was completed as part of the Higher Order Thinking Research Program in the Minnesota Research and Development Center. The purposes of this program of research are (a) increased understanding of the role of vocational education in facilitating higher order thinking capacities in learners, (b) increased understanding of the relationship of higher order thinking processes to the roles vocational education prepares individuals to assume, (c) ways of teaching that support learners in developing higher order thinking capacities, and (d) ways of assessing learning of thinking processes. This program of research was initiated in 1986 with the development of an agenda for inquiry regarding vocational education and higher order thinking (Thomas & Litowitz, 1986). Purpose (b) was addressed by three studies that examined the nature of thought and knowledge underlying competence in work and/or family roles (Anderson, 1989; Cooke, 1988; Johnson, 1987, 1988; Thomas, 1988b). Purpose (d) was reflected in a project which developed and tested a new approach to assessing thinking within the context of work situations (Thomas, 1988a). Purposes (a) and (c) are addressed by the research reported in this publication and its companion Volume I (Thomas & Englund, 1989). The assessment material that was developed and tested in 1988 is incorporated in the research reported here. Space is not devoted here to discussion of the meanings of higher order thinking since these are discussed in the companion Volume I.

Vocational education has historically prepared people for work and family life. Vocational preparation has traditionally helped learners acquire understandings and skills which enable them to engage in activities relevant to an occupation or family life. Job and task analysis has been a central approach to vocational education curriculum development and instructional design. This approach involves observing people engaged in the activities of interest, breaking the activities down into component operations, and identifying and sequencing experiences that will enable learners to master the operations and assemble them to perform the activities. Improvements in vocational education curricula and instruction have focused on improving ways of doing job and task analysis, as well as expanding its scope, bettering testing strategies and procedures, and improving the effectiveness of learning experiences in producing acquisition of understandings and skills.

*Changes in the Nature of Work*

The job and task analysis approach has been functional as long as work and family life activities have remained relatively stable, and as long as activities of interest have been able to be physically observed. Rapid changes occurring in the workplace and in the family are reducing stability and introducing key activities that are not physically observable. Technology has been a major factor in the rapid changes which have reduced the stability and predictability of the nature of work activities. It is no longer reasonable to assume that work activities considered to be central to a job or occupation at a given time will continue to be as important five years later. It may not even be reasonable to assume that jobs existing today will exist in five years. Thus, focusing curriculum and instruction solely on existing activities is becoming a questionable practice. In addition, work and family activities emerging during these changes depend more heavily on complex mental processes that cannot be directly observed. Technology, which now performs many physical operations that used to be done by people, requires skilled operators and maintenance by people who have sophisticated knowledge. Tasks central in operating and maintaining this technology are likely to be mental rather than physical. Thus, those tasks which can be physically observed are not the central tasks being performed. In this way, technology has increased the predominance of mental operations relative to physical operations in work activities.

There are numerous examples of shifts toward greater emphasis on mental activity in work roles. Drafting is no longer as dependent on physical manipulation of drafting tools; computers generate the output of drafting processes. As a result, the importance of physically manipulating drafting tools has declined and drafting has become more exclusively a matter of mental operations. Observing someone physically operating a computer does not provide an understanding of the mental activities central in the task of drafting. Computer-driven machining, which has depended on knowledge of metals and machines, and skill in the physical manipulation of machines, now depends heavily on the mental task of programming computers to drive the machines. As agricultural markets become increasingly world-wide in scope, agribusiness management activities are becoming more complex. Frequent decisions about lines and stocks of products, as well as which enterprises to continue and which to modify or abandon, have become necessary. These decisions involve consideration of a wide range of factors which interact to produce a high degree of uncertainty. Computerization of offices has brought with it the need to understand and manipulate complex software programs and to effectively structure management information systems for highly specific purposes. Such activities draw on an array of complex mental capacities.

Citing such examples carries the risk of implying that physical operations don't involve knowledge, mental capacities, and operations. This is not the case. The point is that complex activities, such as the examples cited above, are largely mental in nature--even when the desired object and some aspects of the activity are physical (Newell & Simon, 1972). The mental aspects of the activities are central to the outcome or result of the activity, and they cannot be observed in the same way as physical activities.

Functions and tasks for which technology does not exist are often characterized by a high degree of variability and complexity. Examples are functions and tasks that require interpretation of social signals or more extensive understanding and interpretation of human beings (who vary widely and are extremely complex). Such functions and tasks are largely mental in nature.

*Changes in Family Life*

The family has also been touched by technological and social changes. Ways of thinking about family roles have become more flexible as multiple members have taken on responsibilities for income production, household management, and child care. As they have become more varied and complex, logistics, patterns, and coordination of everyday activities of family members involve increasingly complex mental work. The simultaneous involvement of several members of a family in work and educational pursuits has necessitated selection and use of services outside the family to meet family members' day-to-day needs. Goods and services that used to be physically produced by families are now selected through decision processes that involve complex mental operations. The wider and more varied involvements of family members have made family roles, relationships, and meanings of family more complex, as well as more ambiguous and open to revision. Family roles and activities are likely to be determined less by adoption of a past or existing pattern than by decisions and choices that entail complex mental processes.

*Alternative Strategies for Dealing with Change*

As work and family activities become less predictable, and as complexity heightens the importance of intellectual processes not easily observed, vocational educators face the need to either modify or rethink their approach to curriculum and instructional development. As concerns about attitudinal and motivational issues, ethics, human rights, cultural diversity, and other affective dimensions of work and family life increase, vocational education is challenged to go beyond its traditional interest in performance to address questions of meaning.

One approach vocational educators might take is to speed up curriculum and instructional development processes. As new work activities develop, they could be observed and analyzed, and curriculum quickly devised to prepare people for the activities in a shorter amount of time. This might be viewed as a "rapid-response" approach. At least three factors mitigate against this solution. One is the expense of task-analysis-oriented curriculum development processes. It is time consuming, and additional resources to support more frequent activity of this type are unlikely to be available. Second, this approach does not respond to the need to understand mental activity as an increasingly central factor in work roles. Third, this approach does not address personal meanings and implications of change, issues that are closely related to people's attitudes and motivations.

A second approach involves preparation of carefully prepared instructions, often in the form of detailed operations or procedures manuals. This approach may be feasible in situations where operation or procedures are not too complex, but fails as the complexity of operations and procedures increases. Anyone lacking a basic understanding of computers or familiarity with the structure of a computer program, and who has tried to interpret computer manuals for complex programs, has experienced the problems with this approach.

A third approach vocational educators might take addresses the need to focus attention on mental capacities and operations. This approach, known as cognitive task analysis (Gagne, 1977; Landa, 1974; Lesgold, Bonar, et al., 1986; Lesgold, Lajoie, et al., 1986), defines cognition in terms of mental tasks, and uses the task analysis process to create hierarchies of nested tasks involved in an activity. These hierarchies are created by using either rational or empirical approaches to task analysis, or some combination of the two. Mental operations are decomposed into their component parts. The parts are then taught and assembled during the learning process. A similar approach has been used in the affective domain to analyze affective understandings and skills (Posner & Rudnitsky, 1986). While this approach succeeds in shifting the focus to mental aspects of activities, and is beginning to focus on attitudes and motivations, its basis in already-defined, existing activities resembles job and task analysis. This approach appears to be effective and most usable when activities and problems are well-defined; that is, when goals are given and mental procedures and processes for accomplishing them can be clearly specified in detail. Thus, this approach holds promise for curricular development and instructional design, when the desired outcome is learning mental or affective aspects of existing, well-defined activities. Learning hierarchies may be useful in combination with the rapid-response approach described previously. They are less useful for activities in which goals and procedures cannot be completely determined in advance. Such activities include those that do not yet exist and those which are "ill-defined." Ill-defined activities are those in which goals and procedures must be constructed. While the affective version of cognitive task analysis addresses attitudes and motivations on a performance level, it does not address these areas at a meaning level. Consequently, its impact on these areas may be superficial rather than deep. Further, like job and task analysis, cognitive task analysis is time consuming and expensive.

### *Purpose and Objectives of the Research*

The emerging importance of intellectual processes in changing work and family activities points to cognitive theory and research as a promising source of theories and concepts on which to base new approaches to curricular development and instructional design. The cognitive-task-analysis approach reflects a move in this direction. The purpose of the research reported here was to apply previously identified cognitive theory and research (Thomas & Litowitz, 1986) to the development of an instructional design model for vocational education that would reduce the limitations of the approaches identified above, as well as more adequately address the range of changing conditions in the workplace and the family. More specifically, the intent was to develop an instructional design model that would (a) reflect the interests of vocational education in real-world work and family contexts and activities; (b) focus attention on the mental aspects underlying work or family activities; (c) address learning goals that include performance, but that also extend to underlying meanings; (d) reduce the separation of cognition from affective and psychomotor aspects of human activities; (e) prepare learners for the world as it currently exists as well as the yet-to-be-determined, not-yet-existing world of the future; and (f) be reasonably practical for vocational education to implement in terms of effort and cost. Specific objectives of the research reported here were to:

1. Develop an instructional design model for teaching mental aspects underlying work and family activities in a context of rapid change and high technology.
2. Test the instructional design model by developing a prototype instructional design for teaching mental aspects underlying activities within a domain relevant to vocational education.
3. Develop materials required by the prototype instructional design.
4. Test the prototype instructional design for effectiveness in facilitating development of the mental aspects underlying activities within the selected domain.

In addition to the importance of providing a test of the instructional design model, an instructional prototype was also seen as providing a concrete example of the application to instruction of concepts anticipated to be new to vocational educators.

# CHAPTER 2

## UNDERLYING THEORY AND RESEARCH

A considerable body of research exists that focuses on cognition in real-world contexts. This research has investigated the thinking underlying activities of people in a wide range of activities which include playing baseball, technical trouble-shooting, bookkeeping, investment decisions, making dairy deliveries, and nonformal teaching (Bhaskar, Dillard, & Stephens, 1983; Chiesi, Spilich, & Voss, 1979; Clarkson, 1962; Luria, 1976; Rogoff & Lave, 1984; Ramsussen & Jensen, 1974; Scribner, 1984). Much of this research has compared people who have reached a high level of expertise in a role, function, or activity, with those who are less competent or who are learning an activity. This research has revealed a close relationship between people's thinking processes, the nature of their knowledge, the meanings they ascribe to events or phenomena, and their level of competence. For example, one study completed by vocational education researchers revealed relationships between technicians' cognitive flexibility and their knowledge structures (Smith & Moss, 1970). This body of research has revealed (a) the importance of domain knowledge and context in learning and thinking; (b) that, in addition to content differences, knowledge domains also differ in their organization; and (c) that it is possible to identify levels of progression or development of people within a knowledge domain by the type of content people express and its organization.

Expert-novice comparison studies completed as part of the Higher Order Thinking Research Program in the Minnesota Research and Development Center for Vocational Education (Anderson, 1989; Cooke, 1988; Johnson, 1987; Thomas, 1988b) have indicated that individuals with more extensively developed knowledge structures attend to deeper, principle-related features of situations and use more powerful, inclusive concepts and principles in their interpretations. In contrast, less-expert individuals focus on surface features detectable through the senses and are more concrete in their interpretations. This research indicates that complex judgment and problem solving involve strategic, selective focusing of attention on cues that are relevant to a problem or goal. Knowledge structures guide this selective attending and are key elements in the interpretations and meanings people generate, as well as in people's effectiveness in dealing with problems and goals. Cognitive research suggests that knowledge structures which support complex thinking are organized in a way that integrates (a) features of the external world, (b) goals or intentions, (c) actions, and (d) domain-knowledge concepts and principles. The organization and content of such knowledge structures is quite different from the disciplinary structures of knowledge reflected so often in printed curricula. While disciplinary concepts are present, they are embedded within action- or meaning-oriented structures that guide interpretations and actions.

The idea that knowledge domains differ, and that there is a close, inseparable relationship between knowledge and thinking, is reflected in the cognitive theories underlying the research reported in this publication. The other central feature in the selection of theories on which this work is based is the theory's ability to integrate internal states of people, features in the external world, and people's actions. Internal states of human beings of particular interest include people's goals, intentions, meanings, and their domain-knowledge concepts and principles. The following sections outline the theories that form the basis for the instructional design model reported in Chapter 3.

### *Task Environments*

The concept of a task environment is central in Newell and Simon's (1972) theory of human problem solving. This theory distinguishes between an environment (which is external to a problem solver) and the problem solver's internal representation of the environment, and focuses on two interacting aspects: (a) the demands of task environments, and (b) the psychological state of actors in terms of intentions and what they know about a task environment that is relevant to those intentions.

#### The External Environment

Because a person's psychological state affects how an environment is perceived, a person's description of an environment reflects their interpretation of the environment in terms of the goal, problem, or task they have in mind, as well as in terms of the state of their knowledge. Environments that can be readily described by almost anyone in simple terms can be easily communicated. Those for which this cannot be done (those which are described very differently by different people) cannot be communicated in a way that assures a consistent message will be received. Complex environments are present in this latter group. For example, a description of a four-legged, 36-inch-square, solid walnut table is more likely to be received as a similar message by many individuals, than is a description of a car's electrical system or a complex human relationship.

#### Internal Representations of the External Environment

A task environment is an environment coupled with a goal, problem, or task (Newell & Simon, 1972). A task environment includes features, people, objects, events, and relationships in the external world, as well as a person's internal representation of those features, people, objects, events, and relationships. A person's internal representation of an environment is selective; it contains only those features, objects, and relationships that are relevant to the person's goals, intents, and interests and that the person's knowledge allows them to perceive. These internal representations guide a person's strategies in planning their moves within the task environment. The nature of a person's internal representation reflects the interaction of a person's psychological state (i.e., the person's goals or motivations and their concepts) with the actual external environment. Numerous possible representations are possible for all but the most simple environments. The same external environment is represented as different task environments by people having different goals or intents and differing levels of knowledge. The goal accepted by the person as something to be attained in a given task environment is the connecting link between the external environment and the person's psychological state.

### *Goals, Intentions, and Actions*

Newell and Simon's (1972) theory of human problem solving takes into account that a person's knowledge and goals influence what they see and pay attention to in an environment. Schank and Abelson (1977) proposed a theory of knowledge structures that focuses on the nature of people's knowledge and the relationships between that knowledge and the meanings, goals, and actions a person formulates or sees in others. Like Newell and Simon's theory, Schank and Abelson's theory assumes a close relationship between knowledge and thinking, and between content and process, and integrates conditions and features in the external world with psychological states of people. The limitations of Newell and Simon's theory imposed by its focus on performance are reduced by combining it with Schank and Abelson's theory, which extends to learning and development (Schank, 1982). Schank and Abelson's knowledge-structures theory also extends beyond goals and task-environment knowledge to meanings as they are reflected in personal belief systems and ideologies which dispose people toward certain orientations in their thinking and actions.

Schank and Abelson's theory pertains to the real-world actions of people, and relationships among actions, purpose, and context. This theory of knowledge structures focuses on human intentions, dispositions, and relationships. In addition, the theory acknowledges the messiness and frequently illogical character of the real world. This theory of scripts, plans, goals, and themes holds that people understand and act in real-world events based on a knowledge system consisting of varying types and levels. Central tenets in this theory are:

1. **Knowledge domain specificity.** Knowledge in one domain may be organized according to principles that differ from those which organize knowledge in another domain. A theory of cognition in a particular domain requires a theory of the domain itself--a description of the more complex structures in memory and their characteristic properties.

2. **Practical reasoning.** Procedures for applying past knowledge to new experiences often seem to require common sense and practical rules of thumb. If rules of thumb are not available, reasoning about specific actions for specific problems or situations in addition to, or instead of, formal analysis is used.

3. **Schematized knowledge.** Knowledge is organized in chunks or packages so that with one or more cues, many inferences are possible about what might happen in a given situation.

4. **Multi-level knowledge structures.** Knowledge is organized in multi-level structures which include (a) small units of meaning reflected in statements of description or relationship at the lowest level; (b) structural links that specify types of relevant information at the middle level; and (c) large, abstract, over-arching thematic structures at the top level, which organize and index the more specific information contained in the lower levels.

5. **Functional flexibility.** Knowledge structures have functions--they aid comprehension, organize memory, and guide learning and abstraction. They are flexible in that the mental processes that use them can be combined to serve multiple purposes.

The multi-level knowledge structures in Schank and Ableson's (1977) theory range from scripts at the most specific level to themes at the most general level. Individuals determine meaning for events by placing a piece of information in context: A plan is sensible if the goal it leads to is understood; a goal is understandable if it is part of a larger theme. These types of knowledge structures and their types of content and functions are described in the following paragraphs.

Scripts

Scripts contain appropriate sequences of events in a particular context (Galambos, 1986; Reiser, 1986; Schank, 1982; Schank & Abelson, 1977). They reflect stereotyped sequences of actions that define well-known situations. Since scripts are assembled to support routine actions which require minimal amounts of conscious processing, they are not a central focus in the research reported here. An example of a script familiar to many people is eating in a restaurant.

Plans

An unfamiliar situation where no scripts apply requires planning. Planning is harder than using a script because it requires a great deal of thought about conditions of applicability. Planning is the reasoning by which an individual decides upon one or more actions (Abbott & Black, 1986; Leddo & Abelson, 1986; Schank, 1982; Schank & Abelson, 1977), the choosing of a path to a goal. Plan knowledge structures are made up of general information about how people achieve goals. A plan is a series of actions one could or would perform to attain a particular goal. Plans are rule-bound knowledge structures that have the following functions: (a) describe the set of action choices a person has when setting out to accomplish a goal; (b) allow a person to detect, understand, and judge the relevance of particular methods to the achievement of particular goals; (c) allow actions that did not work to be adjusted; (d) enable access to information about possible problems which could arise in activities; (e) enable explanation of sequences of actions in light of a goal they are intended to achieve; (f) enable predictions about what will occur in an event; (g) connect cues in external environments, goals internal to people, and acts that can be carried out in the external environments to achieve those goals. Far-reaching goals require more planning to achieve than do less far-reaching goals, because they often require that smaller subgoals be identified and that plans be developed to achieve those subgoals.

The above discussion of plans indicates that both planning and understanding use plan knowledge structures. However, constructing plans and understanding plans are different processes. Constructing plans involves choosing a path to achieving a goal, stringing methods together in an admissible or optimal way to achieve a given goal. Plan creation is problem solving. Understanding involves creating connections, not creating one's own plan. Understanding involves reconstructing someone else's plan, ascertaining a person's goal and recognizing their actions as attempts to realize that goal. By finding a plan in one's own knowledge structure, a person can make guesses about the intentions underlying another's actions. Plan understanding involves very broad knowledge of large numbers of actions and goals, and also allows evaluation of one's own or another's plan as to whether the plan was well formulated or is the best that could have been developed.

Goals

As implied above, plans are linked to goals. A goal is the item, event, or state desired and typically involves a change from a current state to a desired one. Goals are intentions that arise from individuals' states and from the interaction of those states with external environments. Goal structures have been characterized as hierarchical structures consisting of main goals and subgoals (Abbott & Black, 1986; Galambos, Abelson, & Black, 1986; Newell & Simon, 1972; Schank & Abelson, 1977). The highest level is the main goal. Main goals organize subgoals. Subgoals contribute to and actually accomplish main goals. Instrumental to the subgoals are plan actions (already described) which appear at lower levels in the goal structure. Goals appear to have the very crucial function of structuring and indexing information in memory so it can be located when it is relevant (Anderson, Spiro, & Montague, 1977; Bobrow & Collins, 1975; Glass, Holyoak, & Santa, 1979; Reiser, 1986).

Themes

Themes are broad, overarching principles, and concepts that give rise to goals. Themes generate and reflect clusters of related goals that tend to occur together. Themes make goals understandable in that they provide a larger context for isolated goals (Kay & Black, 1986; Schank, 1982; Schank & Abelson, 1977; Seifert, Abelson, & McKoon, 1986). These general, high-level knowledge structures store together in memory a wide range of highly varied situations from a variety of contexts. Constructed from experiences with specific cases, events, or activities, themes organize episodes which may vary greatly in their specific features into patterns that reflect abstract similarities. Because themes are based on thematic similarity, they are context independent. Thus, they can facilitate transfer of goals and plan actions across a wide range of types of situations. Themes provide knowledge relevant to making predictions, deriving expectations and explanations, categorizing, and planning. For example, themes contain the background information that enables predictions of an individual's goals. Themes concern types of goal relationships, opportunities, and difficulties often encountered in pursuing goals, and implications for goal success or failure. Like the goal-action structure, themes are believed to be used both in organizing memory to aid retrieval and in interpreting new experiences. Types of themes include role themes, interpersonal themes, and life themes.

### *Implications of Task Environments and Knowledge Structures for Vocational Education*

What insights do the theories described above and the cognitive research involving people at varying levels of competence provide regarding the design of instruction? What questions do they raise? What are their implications for vocational education? This section will briefly address these questions.

#### Person-Environment Interaction

The theories reviewed in the previous sections suggest a close relationship, or interaction, between people and their environments on several levels. On the psychological level, people's goals, intentions, and motivations influence what they perceive in a problem or situation. Also on the psychological level, people's knowledge states influence what they perceive. People at different levels of development in task-environment-relevant knowledge will perceive essentially different task environments in the same external environment. Furthermore, the same paths in task environments are not available as paths to the goal (plans) for people at different levels of development (Newell & Simon, 1972). An implication for instruction is that instructors cannot assume that environments to which learners are exposed during instruction are the same for all learners, or are the same for learners as those environments are for an instructor. Learners will experience environments in the way their level of knowledge and their goal state orients them, not necessarily in the way their instructors intend. An understanding of task environments, their demands, and their meanings for people with different goals and levels of knowledge, requires study of external environments through the eyes of people at varying levels of experience and knowledge. On a physical or social level, people's acts in environments affect environments in some way. Physical or social changes in environments also have an impact on people's knowledge. Thus, to think of "the" task, or "the" environment, is to oversimplify. Instead, a concept of learner-environment interaction is suggested.

#### Specific Nature of Domain Knowledge and Task Environments

At first glance, knowledge-domain specificity seems troublesome, especially given the issues raised in Chapter 1 concerning rapidity of change and the need for flexibility in applying knowledge to new, unfamiliar situations and problems. If knowledge needs to be specific, how can it be generalized? It is important here to distinguish between specific domain and specific knowledge. These theories suggest the importance of a deep understanding of the nature of the knowledge domain of interest, including its higher levels, the nature of the thinking processes that draw on it, and its central task environments conceptualized at varying levels of abstraction. Both more general, concept- and principle-level knowledge and more specific, factual level (specific) knowledge is relevant in a domain. Further clarification of this point will be made in subsequent sections of this publication.

The Need for a Picture of Development Within a Domain

The importance of a person's knowledge state in terms of what the person perceives and attends to in an environment suggests three things: (a) that it is important to know the extent of prior knowledge development of learners before assuming the appropriateness of any given instruction; (b) that because people at different levels of knowledge do perceive and focus on very different things in an environment, their perceptions, interpretations and analyses offer valuable clues to their stage of knowledge development in a domain; and (c) that the characterization of development needs to be specific to the domain in order to be highly useful for instruction.

The Kind of Knowledge that Should Be Taught

A deep understanding of the knowledge domain is likely to assist in determining where to focus instruction. An understanding of the knowledge domain will clarify the function of the different structures it contains. Plans generate actions; goals generate plans; themes generate goals. Small-scale social and technological change is likely to bring about the need for changes in plans. Such changes require alterations in the ways people do things and how certain goals are achieved. Larger-scale change brings about changes in goals. Paradigmatic change is theme-level change. An understanding of change in terms of the knowledge levels for which it has implications is an important basis for decisions about the aims of curriculum and instruction.

Ways of Teaching the Kind of Knowledge that Should Be Taught

While the theories discussed here are useful in aiding understanding of relationships between people's mental states and their interpretations and actions in environments, the theories are of more limited help in illuminating how people develop task-environment representations, plans, goals, and themes, and how such development might be facilitated. Some reflection on the theories and Schank's (1982) more recent work gives some clues, but beyond these, other theories are needed to address the question of learning and teaching. Such theories will be discussed in the next main section, entitled Research on Development and Learning.

The theories of task environments and knowledge structures do suggest some instructional practices. These practices include:

1. Being thoughtful about the level at which task environments of interest in instruction are conceptualized and the level at which instructional goals are set, and helping learners develop

conceptualizations of relevant task environments based on deeper features that are linked to principles.

2. Enabling learners to develop goal-action structures by involving learners in identifying goals underlying situations and actions, in searching for and predicting actions that relate to given goals, in explaining why certain actions were done, in critiquing actions with respect to their consequences for goals, and in understanding others' explanations, predictions, and critiques.

3. Enabling learners to develop theme structures by exposing them to many cases that differ in context but are similar in thematic principles, and by engaging learners in explaining goals in terms of themes, in considering the consequences for themes of holding alternative goals, in predicting goals given themes, and in critiquing goals in terms of themes.

4. Helping learners to develop the habit of, and capacity for, doing these things on their own, independent of the teacher.

Examples of Applications in Vocational Education

The interest reflected in the theories described above in real-world environments and events, and in the organization of knowledge for understanding real-world actions of people, is relevant to vocational education. Domain-specific knowledge structures and thinking processes studied over the past five years in the context of vocational education in research sponsored by the Minnesota Research and Development Center for Vocational Education, and in doctoral dissertations completed in the Department of Vocational and Technical Education at the University of Minnesota, reflect these theories. One study explored knowledge structures and thinking processes underlying technical trouble-shooting (Johnson, 1987; Johnson, 1988). In these task environments, the main goal is usually given (e.g., to find the fault in a device or system) and the person's task is to generate subgoals and select or develop plans that will accomplish the subgoals. Finding the fault in a device or system is facilitated by an understanding of the subsystems existing in that device or system, and how they function and interrelate. The knowledge structure underlying this kind of activity as experts perform it is a mental model of the task environment (the system and its subsystems) (Rasmussen & Jensen, 1974). Thinking is driven by hypotheses generated about the states of the subsystems. These mental, model-type structures are relevant to industrial education and agricultural mechanics, and, with extension to biological systems and subsystems, to health education and to plant and animal health in agriculture. Mental models may also be potentially relevant in business, marketing, industry, and home economics areas that focus on production and distribution systems.

A second type of knowledge structure was revealed in studies of knowledge domains underlying interactions between people. These structures were found to be organized in terms of contextual, physical, and social features of task environments and on states, conditions, goals, and meanings of people (Cooke, 1988; Thomas, 1988a). In such task environments, main goals may be given. Often, however, main goals as well as subgoals and the plans for achieving them must be established as the interaction proceeds. Thinking processes focus on interpretation of states, on invoking relevant themes, and on goal and plan selection and formulation. These structures are relevant to vocational education in home economics areas including parenting, child care, family life education, as well as to the sales aspect of marketing education, and the preparation of supervisors, trainers, and teachers.

A third type of domain-specific knowledge structure studied is that underlying complex decisions or choices. These require finding a sufficient or optimal match between a set of conditions and an array of alternative options or strategies. This kind of knowledge structure was studied in the context of housing decisions (Anderson, 1989). Earlier studies exploring this type of knowledge structure in the context of economic investment decisions (Clarkson, 1962) identified a "decision net" of factors through which conditions and options were filtered to arrive at a match. Examples of vocational education areas in which this type of knowledge structure has potential relevance include economic management and decision making, and strategic planning related to business and household management and enterprise management in agriculture.

It is anticipated that there are a number of additional types of domain-specific knowledge structures that are also relevant to vocational education. Furthermore, the types of knowledge structures identified above may be used in combination with each other in certain kinds of task environments. These issues need clarification through additional research. The main points to be made here are that (a) the organization of knowledge appears to differ in relation to the kind of task environment being dealt with, and (b) the kind of thinking that is done regarding a task environment appears to be associated with the type of knowledge organization involved. Differences in knowledge structures reflect differences in the nature and structure of task environments, both in the degree to which tasks require that goals must be generated, and in the nature and variability of the goals. The knowledge-domain studies referred to above support Newell and Simon's (1972) point that there is a crucial interdependence between task environments and goals. This interdependence allows task-relevant components of the task environment to be separated from task-irrelevant components, and enables knowledge about task environments, plans, and goal-plan relationships that people have available to be brought to bear on tasks or problems.

*Research on Development and Learning*

Cognitive research suggests that individuals who have reached advanced levels of understanding in one knowledge domain may be at very elementary levels in their development in another knowledge domain. This evidence has led to a domain-oriented view of development. In this view, development is reflected by the degree of complexity and integration a person's knowledge structure has attained. Learning has come to be viewed as the construction of increasingly elaborated, complex, and integrated knowledge structures.

## Development Within a Knowledge Domain

Researchers have identified developmental progression in a knowledge domain in terms of the nature of concepts or constructs that appear in people's written and oral expressions regarding problems or explanations. Understanding of patterns of development within a knowledge domain have come both from studies that either (a) compare individuals who are at different levels of development, or (b) follow the same individuals across stages of development. Expert-novice studies compare individuals who are at different levels of development. These studies have shown that experts attend to deeper, principle-related features of situations and use more powerful, inclusive concepts and principles in their interpretations, while novices focus on surface features detectable through the senses and are more concrete in their interpretations. Experts focus selectively and strategically on cues that are relevant to a problem, task, or goal; novices attend to a wider array of cues and pay as much attention to those that are irrelevant as to those that are relevant.

Other studies have focused on characteristics of the concepts used by people with high- and low-domain knowledge in describing, analyzing, and explaining domain-relevant problems, situations, and events (Langer, 1980). Individuals who possess extensive, highly developed knowledge use superordinate concepts and definitions and express analogies and links that reflect abstract relationships. People with moderate knowledge development cite examples and give attributes and defining characteristics. People with very little domain knowledge development make links to personal experiences and cite concrete instances rather than concepts. Developmental studies of children reveal a similar progression in abstraction, from instances and categories of objects and their properties that are directly perceptible by the senses, to properties and relations that are determined by operating on and classifying objects (Lunzer, 1986).

Levels of abstraction within the workplace have also been characterized (Jaques, Gibson, & Isaac, 1978). One characterization of these levels is in terms of goals and plans (Stamp, 1978). At the lowest levels, goals are not generated but plans may be developed. At a middle level, goals and plans are generated in terms of rules (procedures), or forms (patterns). At a high level, new patterns of goals and plans are generated that reflect unique aspects of situations.

## Learning as Construction of Knowledge

Research on learning is increasingly indicating that true understanding, which reflects higher levels of knowledge, is constructed rather than received directly from another person-- "Wisdom can't be told" (Bransford, Franks, Vye, & Sherwood, 1986). People make sense of their environments by constructing meanings to which th tter.d. These meanings enable people to see situations in certain ways and guide their actions. Ove ne, people develop repertoires of such constructed meanings, known as knowledge structures. Because people's knowledge structures influence what is noticed and attended to, and interpretations of experiences, prior knowledge influences new learning. Knowledge construction during the learning process reflects and occurs within this already present structure. This explains why it is often difficult to help learners change their views and ways of doing things. The knowledge structure that learners bring with them has been established over several years of experiences. Unless learners' educational experiences result in construction of a new cognitive organization that integrates, modifies, and elaborates the old structure within a new one, old structures are likely to continue to guide thinking and actions and new learning is likely to remain inert.

These views of learning suggest that learning may be defined as changes in knowledge structures. Ways in which knowledge structures change have been identified by Rumelhart & Norman (1978) as follows:

1. New elements are added to old structures but the old organization remains intact.
2. New linkages are formed creating larger "chunks" in the knowledge structure.
3. New organizations occur which reorganize and embed previous structures within new structures that have more encompassing elements at their organizational centers.

Cognitive research has also indicated that, in addition to constructing and integrating knowledge structures, people also learn programs for drawing from their knowledge structure in order to interpret and create actions for unique situations. In other words, they learn to compile their knowledge in ways that make it applicable to differing situations (Anderson, 1985; Schank, 1982).

Factors that Support Construction of Knowledge

The first factor, fidelity, is the correspondence of the features in a simulated or learning situation to the eventual situations learners are likely to encounter (Elstein, Shulman, & Sprafka, 1978). Fidelity in terms of "deep features" (features which require more superordinate, generalized, abstract knowledge to see, and can only be inferred from more specific, concrete events or objects) is especially important. Fidelity is especially important, for example, in helping learners construct relational concepts. Constructing such concepts requires exposure to situations, problems, or tasks in which instances of the complete relationship exist (Joyce & Weil, 1986). Fidelity to the context in which learners are expected to later construct or recognize concepts is also important. If learners need to see relationships embedded in a context containing many irrelevant as well as relevant details, learning experiences should provide that kind of context. Learning experiences that present only what is relevant offer no opportunity for learners to acquire the selection capacities they need to extract the relevant cues which signal a concept's presence in the real world. Furthermore, if real-world situations involve detecting and using feedback from the environment during the process of solution, learning situations need to provide such feedback so learners can develop the capacity to recognize and use it in monitoring their own actions.

The second factor, visualization, focuses on visual images. Visual images appear to penetrate deeply into cognitive structures (Reiser, 1986). Although there appear to be individual differences in the extent to which people are visually-oriented in their thinking, images of past experiences appear to be especially recallable and may be a major avenue through which other relevant memories are activated. The capacity of the human perceptual system to represent large amounts of highly complex information at a glance and store that information in memory with great accuracy and durability is well developed (Spiro et al., 1987). Because of this, the perceptual system is ideally suited to facilitating the representation of complexity and the recognition of resemblances across cases.

Third, range and depth of experience contribute to people's construction of knowledge. Range of experience refers to the degree to which experiences vary. A wide range of experience provides rich opportunities to compare similarities and differences and to extract generalizations. Construction of theme-level knowledge structures is dependent on range of experience. Development of theme-level knowledge requires exposure to a wide range of experiences that differ on surface features, but are similar on deep-level principles or concepts. Depth in experiences refers to the amount of a type of experience and to the level at which experiences are encountered. Deeper experiencing is extended in time and engages many intellectual facets as well as emotions; it involves detailed examination and analysis of problems and situations and is personally involving.

Criss-crossing the landscape is an instructional principle that provides depth and range of experience (Spiro et al., 1988). In relation to this principle, a knowledge domain is viewed as a conceptual landscape. A landscape has many sites which share some features and are different in other features. A landscape is understood by exploring it from many directions, crossing it first this way and then that. In this approach to instruction, specific cases are "landscape sites" which have partially overlapping features. "Case sites" are re-visited and analyzed from a number of different directions and perspectives. By repeating the presentation of the same case in relation to different concepts or perspectives, the multifaceted character of the case is revealed to (constructed by) the learner. This process is crucial for transfer to unfamiliar situations. It frees the learner from a rule-bound approach and develops multiple perspectives, points of view, and systems of classification which can accommodate the variability that differing contexts introduce (Spiro et al., 1987; Spiro et al., 1988).

Finally, mediation of learners' experiences by external sources influences the interpretations or meanings learners place on their experience. Mediation contributes to the form knowledge structures take by influencing what become the structural centers of learners' knowledge structures (Luria, 1982; Vygotsky, 1978). Mediation entails focusing learners' attention on certain features that are relevant to some goal, problem, or perspective; highlighting cues present in an environment; or providing certain interpretations of events, actions, and conditions.

### *Summary*

In summary, theories which integrate knowledge, motivations, actions, and environments have particular relevance to understanding and affecting the system of concepts and mental processes that direct people's involvement in real-world activities of interest in vocational education. Learners' roles in the construction of such systems of concepts, or knowledge structures, have implications for the way vocational education conceives of and structures instruction. Four factors were identified as particularly significant in supporting learners' knowledge construction: (a) fidelity of the learning situation to the real world, (b) use of learners' perceptual system through incorporation of visual images, (c) range and depth of learners' experiences, and (d) mediation of learners' interpretations of their experiences.

# CHAPTER 3

## INSTRUCTIONAL DESIGN MODEL

This research sought to develop and test an instructional design model that would support learners in constructing knowledge structures that have the following characteristics and functions: (a) integrate features of the external world, domain-knowledge concepts and principles, and goals, intentions, and actions; (b) enable selective, strategic focus of attention on deep-level features; (c) facilitate interpretations in terms of more powerful, superordinate-level concepts and principles; and (d) support sensitivity to subtle but important variations among cases. The following sections describe the instructional design model and the prototype instructional design that was developed to test the model.

### *Develop a Theory of the Knowledge Domain*

The theories outlined in Chapter 2 emphasize the content and function of knowledge structures. They assume that a theory of a knowledge domain is a necessary aspect of understanding domain-related thinking and actions. It follows that instruction intended to affect domain-related thinking and actions should begin with an understanding of domain knowledge and the mental process-knowledge interactions that characterize the domain. This knowledge-domain theory does not entail outlining all of the specifics of domain content. Rather, it involves developing an understanding of the nature of the knowledge structures, particularly at the higher, more over-arching levels of knowledge entailed in a domain, in terms of their type of content, their organization, and the nature of their interaction with mental processes that is most critical.

Real-world problems are often complex and "messy." They have irregularities and partially overlapping characteristics which defy neat boundaries and categorizations. Much of the application of cognitive theory to instruction has emphasized (a) well-structured domains that vary uniformly and systematically (e.g., mathematics); (b) domains that are context-independent (e.g., general, scientific concepts); or (c) domains that are limited to a small set of concepts and goals (e.g., interpreting simple sentence strings or strings of terms). A complex, ill-structured domain has many concepts that are relevant, which interact with the specific context in which they are set, and which have inconsistent patterns of combination across case applications of the same type (Spiro et al., 1988). Many real-world problems reflect these characteristics. Domains that concern human beings, especially their social or psychological aspects, typically meet the criteria for being both complex and ill-structured. Because prior research (Thomas, 1988a) on knowledge underlying working with children had already provided a start on a theory of a knowledge domain, and because this domain met the criteria for being complex and ill-structured, it was chosen as the domain for development of the instructional prototype.

Developing a theory of the knowledge domain entailed gaining an understanding of the knowledge domain as a composite of varying types and levels of knowledge structures. The process of knowledge-domain theory development entailed describing the domain's task-environment structures, goals, and subgoals, as well as plan-action and theme structures. This was done using a combination of empirical and rational approaches. Details of the processes and procedures used in developing a theory of the domain, as well as the domain theory that was developed, are presented in Volume I of this publication series (Thomas & Englund, 1989). The knowledge domain that was developed focused on supporting children's social development and included the following:

1. Task environment including children, activities, and contextual, physical, social, and time aspects of the environment
2. Ten child-focused social-development main goals and relevant subgoals and action plans
3. Decision rules for determining priorities among goals
4. Two illustrative, contrasting themes

This domain theory provided an understanding of the nature and organization of content relevant to each type of knowledge structure.

The second aspect of a knowledge-domain theory is a description of the interactions between knowledge and mental process. These were identified by imposing the knowledge-structure theory on data that had been collected previously, which contained analyses of specific situations. Individuals at varying levels of educational background, experience, and expertise in working with children were asked to provide an analysis of 23 video-taped situations involving adults working with children. The analyses focused on actions the adult took, their appropriateness, and further actions that could or should have been taken. These analyses were content analyzed for the mental processes reflected and for the kind of knowledge structure involved in each process. Table 1 reveals a summary of the results of this analysis.

### *Describe Development Within the Knowledge Domain in Terms of Nature of Knowledge Structures and Knowledge-Thinking Process Interactions*

Developing an understanding of development within a domain of knowledge focuses on two aspects of the theories presented in Chapter 2: (a) person-environment interaction, and (b) the need for characterizing what constitutes development within a domain. Development within the knowledge domain of supporting children's development was accomplished by imposing more general theories of conceptual development (Jaques et al., 1978; Langer, 1980; Lunzer, 1986) on the interpretations of situations data described above, on the knowledge structures that were identified, and by

Table 1

Mental Process-Knowledge Structure Interactions

| Type of knowledge structure | Mental process: Explain | Predict | Evaluate |
|---|---|---|---|
| Plans | Explain how an action fits within a series of actions; explain problems that occurred in the execution of actions | Predict what actions will come next, what events will occur next; predict problems that may arise in activities | Judge the appropriateness of an action's sequential or other position in relation to other actions; judge how well an action was executed |
| Goal-plan structures | Explain actions in terms of goals; explain consequences of actions in terms of their impact on goals | Predict what actions are likely to be used or which could be used for a known goal; predict which actions might accomplish a goal; predict what problems might occur in using certain actions to accomplish identified goals | Judge actions in terms of their effectiveness and/or appropriateness for accomplishing particular goals; judge consequences of actions in terms of their impact on goals |
| Themes | Explain goals in terms of what people are like--their natures, assumptions, and beliefs; explain consequences of goals in terms of their impact on themes | Predict what goals or actions are likely based on principles that are operating, what people are like, what their assumptions and beliefs are; predict what will happen, what problems may arise in relation to patterns of goals | Judge goals in relation to each other in light of priorities, consistency, relevance, and other theme-level principles; evaluate consequences of goals on themes |

integrating patterns that had been discovered in others' research (Champagne, Klopfer, & Gunstone, 1982; Clement, 1982; Clement & Brown, 1984; Spiro et al., 1988) into the synthesis. The result of this process was a knowledge-domain-anchored developmental chart which is summarized in Table 2 and elaborated in more detail in the Appendix.

Table 2

Developmental Levels Based on Relating Knowledge-Structure Theory to Knowledge Domain

| | Learner level | | |
|---|---|---|---|
| Characteristics | Beginner | Intermediate | Advanced |
| Knowledge structures available | Possesses task-environment knowledge--terms, concepts, principles | Possesses plans for predetermined goals | Possesses themes which have been self-constructed |
| Orientation in understanding, explaining, and summarizing situations, tasks, or problems | Describes sensory-apprehended events | Applies rules; determines causes for task-environment conditions and people's actions; determines consequences of actions on task environment and on predetermined goals | Focuses on underlying beliefs, assumptions, and perspectives about the nature and qualities of human beings and their relationships, and on implications and consequences of goals for themes |
| Avenues used to affect situations, tasks, or problems | Recalls past personal experiences; trial and error | Generates plans for predetermined goals | Generates theme-based goals and relevant plans uniquely tailored to persons and situations; generates new themes |

Table 2 reflects differences in knowledge underlying each level of development. This way of conceptualizing domain-related development suggests instructional goals that focus on development of the type of knowledge structure the individual has begun to develop or on the type of structures that characterize the next highest level of development.

*Identify Potential Learning Environment(s) that Will Enable Learners to Construct the Knowledge Domain at Their Level of Development*

The factors of fidelity, visualization, range and depth of experience, and mediation were considered in relation to the nature of the knowledge domain, the knowledge structure-mental process interactions summarized in Table 1, and the developmental progression summarized in Table 2. What learning experiences, environments, and media would address these factors, types of knowledge, and knowledge-process interactions? This process pointed to the potential usefulness of a computerized video-disc-based learning environment in enabling learners to construct knowledge structures relevant to the selected knowledge domain.

Fidelity

Because visual and auditory cues are often indicators of deep-level features of adult-child interaction, incorporation of video-taped, real-world situations was seen as a way of providing fidelity in the learning environment. Video-taped situations containing the concepts and relationships of interest were seen as more adequately addressing the fidelity factor if they were actual rather than staged situations. The video camera is able to record an environment without interpreting cues and features for those who will view it. It should be noted, however, that even the process of recording a video tape is interpretive and selective to the extent that some aspects of a situation are taped and some are not. The video camera records (a) surface and deep features alike, (b) cues that are more obvious and those that are subtle without calling attention to either, and (c) aspects of an environment that are both relevant and irrelevant to a goal, purpose, or task. Thus, video recordings of actual situations leaves the job of extracting factors to learners--a task learners must perform in real-world situations. Furthermore, because human-interaction situations entail many varied and complex cues, they are difficult to describe in all their richness in written- or verbal-description form. The difficulties in portraying environments of this complexity and variability in a form that captures all relevant features without pre-interpreting them for the learner are largely avoided by the use of video-taped situations. For these reasons, video-taped situations of adult-child interaction were seen as providing opportunities for learners to perceive situations in terms of their own stage of knowledge-domain development in much the same way as learners will do in the real world.

It may be feasible to achieve fidelity for less-complex environments through the use of diagrams, photographs, and forms of representation other than video. The important points to remember are:

1. Representations of environments which reflect considerable interpretation are likely to have lower fidelity for learners in relation to real-world environments and may be undiscernible by them as the task environment that is intended in the instruction.

2. Representations need to contain the kind of mix of cues and features that real-world situations are likely to contain. This does not mean they must contain the exact cues. It does mean that

representations used in instruction should contain surface and deep features, obvious and more subtle cues, and relevant and irrelevant features.

## Visualization

Human interaction, as it occurs in the real world, portrays vivid visual images that are lost when these interactions are diagrammed or otherwise translated into symbolic forms. Verbal descriptions of interactions can produce mental images if persons reading the descriptions have had experiences that enable them to mentally create the images being described. Person-task environment relationships suggest that there is likely to be a wide range in learners' visual images of interaction patterns if they are required to generate them from verbal descriptions. For these reasons, the principle of visualization also supported the use of video-taped situations in the instructional prototype.

Visual images can be provided in forms other than video, of course. Visual images of less complex and more static environments may be able to be captured in diagrams, charts, photographs, or other media. In choosing the form of visualization, consideration of the kinds and complexity of images can help in determining which forms are applicable. Images of children and of interaction are dynamic. The moves and changes are among the most important aspects to visualize. Further, deep features revealed by interactions of adults and children are often complex and subtle. Thus, for this domain, the ability of video tape to provide dynamic and complex images was an important consideration.

## Range and Depth of Experience

The combination of video-taped situations and computer control are both important in the ability of a computerized video-disc-based learning environment to provide a range of different experiences and depth with respect to any given experience. With respect to range of experience, video-taped situations can expose learners to many real-world situations containing knowledge-domain representations that would take learners much longer to gain exposure to through real-world experience. In other words, video-taped situations can concentrate a wide range of experiences in a compressed space of time. Computer control of the video allows the situations to be experienced in a variety of sequences, another aspect of range of experience. Computer-controlled video is also an important factor in providing for depth of experience. A computerized video-disc learning environment allows learners opportunities for repeated and detailed examination and analysis of situations because learners can control the frequency and pace of situation examination. The situation can be "slowed down" or "replayed" in contrast to real-world experience which occurs at an uncontrolled pace and time, and may vary too greatly and too quickly to allow patterns to be discerned by learners.

Mediation

Mediation highlights features, draws learners' attention to certain patterns or occurrences, and may provide a lens through which to view a situation. Because computers can easily shift learners' focus of attention with respect to a situation, a single situation can be viewed from several perspectives and, thus, provide considerable depth of experience. Mediation is one way in which deep-level features of situations can be highlighted. While mediation of experiences can be provided by teachers or other sources external to learners, using computers to mediate learning assures that all learners are exposed to mediation. The form of the mediation can be varied according to learner needs if computer programs are sophisticated enough to provide for this. Mediation can be interjected at strategic, critical times throughout the learning process; these times can be determined and controlled by either an instructor, learners, or the computer.

The type of mediation provided needs to be governed by the developmental stage of learners. Beginning learners who are learning basic concepts and principles in a discipline, and using the concepts and principles to interpret environments, need mediation that helps them connect the concepts and principles with actual events and conditions in the external world. Mediation which helps beginning learners see below sensory-detected patterns to patterns that indicate deeper, principle-dependent features will help them move to a higher level of development. Intermediate learners who are in the process of developing goals, and links between goals and plans that can accomplish the goals, need mediation that focuses their attention on goals and on the connections between goals and actions. Mediation for learners at this level might be in the form of questions that guide learners to (a) look for goals underlying situations and actions, (b) look for and predict actions that relate to given goals, (c) explain why certain actions were done, (d) explain situations in terms of goal-action connections, (e) critique actions with respect to their consequences for goals, and (f) compare their own explanations, predictions, and critiques with others at the same or differing learning levels. Advanced level learners who are in the process of developing themes and learning to generate goals from them are supported by mediation that focuses their attention on connections between themes and goals. This level of mediation might take the form of asking learners (a) about similarities and differences in cases that differ in context but are similar in thematic principles; (b) to explain the sources of goals; (c) to consider the consequences of goals for themes; (d) to predict goals of people for whom they have information about perspectives, beliefs and orientations; (e) to critique goals in relation to certain themes; and (f) to compare their own perspectives, explanations, predictions, and critiques with those of others at the same or differing learning levels.

*Develop a Structure Within Which Strategically Mediated Learner-Environment Interaction Can Occur*

The way in which learners experience environments is the central question here. Should environments be grouped on the basis of goals? Task environment features? Themes? To how many environments must learners be exposed? How often should mediation be provided? In relation to what learner patterns? In relation to what environment patterns? These and countless other questions are answered one way or the other when learning environments are structured. Because the structure of the learning environment depends on the level of the learner, the nature of the knowledge domain, and the nature of domain-related environments, structuring is a matter of judgment more than rules. However, some general considerations will be provided here, as well as a description of the specific structuring that was done in the prototype and the reasons underlying that structuring.

<u>Selecting and Creating Visual Images</u>

Structuring a computerized, video-disc-based learning environment involved creating the video and designing the computer program to reflect the considerations with respect to fidelity, visualization, mediation, and range and depth of experience discussed above. Ninety-three, non-staged vignettes of typical situations relevant to children's social development which reflected the knowledge domain were video taped in actual work settings. With the help of a panel of experienced, expert practitioners in the domain, each vignette was analyzed in terms of the aspects of the knowledge domain it reflected. Twenty-three vignettes were selected to represent, within the space limitations of a two-sided laser disc, as much of the knowledge domain as possible. In addition, other criteria for vignette selection included encompassing as wide a range of situations as possible, including situations with both surface- and deep-feature similarities and differences, and including a range of work-personnel-expertise levels. A master video tape was produced containing the twenty-three vignettes. A master, level III video disc containing 54,000 video frames on each side was then pressed from this video tape. Each frame on the disc was assigned an index number. The index number allows the computer to find the location of specific frames on the video disc.

<u>Creating the Environment's Structure</u>

A concept of knowledge structures as momentary assemblies (Newell, 1981; Schank, 1982; Spiro et al., 1987), rather than as static structures having rigid boundaries and content, underlies the structure of the computer program that was developed. An analogy may be helpful here. Statistics programs that run various analyses on a file of data produce graphs, charts, and numerical summaries. A graph or chart that appears on the screen reflects a momentary picture of the data that disappears when one is done looking at it and closes the screen. The graph or chart no longer exists. To review the chart again, one simply re-runs the program on the same data file and the same chart reappears. Furthermore, the same program can be run using different data sets to produce charts and graphs that may look quite different from one data set to the next. The computer programs that were designed for the beginning and intermediate levels of the prototype learning environment represent models of such a "knowledge-assembly" program.

Each of these programs was constructed around a central "tree" or "spine" structure to which relatively small knowledge strands could be attached. This allowed different central trees or spines to be configured to represent different organizations of the same knowledge. These types of structures also allowed the same knowledge to be recombined with different knowledge. For example, the central tree for the beginner level program was structured on the basis of aspects of the task environment. This tree was a program for combining knowledge about children with knowledge about activities, and physical and social environments. The central tree for the intermediate level program was structured on the basis of main social-development goals and related plans. These trees are shown in Figure 1. Small strands or packages of knowledge were developed which could be linked in the computer program to the tree(s) in which they were relevant. Video was incorporated in the knowledge strands. Thus, a single knowledge package (and its video segments) could be used several times, but each use involved different relationships and different purposes--linkages to different parts of the knowledge structure. This type of program structure was seen as reflecting the same kind of flexibility intended as a characteristic of the knowledge structures learners would construct through experiencing the learning environment.

The concept of criss-crossing the landscape was employed in the use of the scenes as cases on the video disc. Each scene was incorporated several times, in several different knowledge strands. Each time it was included, it was used in relation to a different concept, plan, or goal (landscape "sites"). Thus, the same scene was explored from many directions.

Since individuals are likely to be at varying stages within a level of development, special structures were included in the central trees. One of these structures was referred to as a "bud;" the other was referred to as a "tendril." Because the knowledge structures regarding the task environment and plans, goals, and themes needed to function together as a total knowledge system rather than as discrete, separate structures, opportunities were provided for learners to link them together and integrate them. Buds and tendrils were aimed at these linkages. A bud is an introduction to the next level in relation to the current level. A bud structure was included in both the beginner and intermediate level programs. It set the stage for the next level of development by linking learning at the present level to learning that was to come in the next level.

Buds in the beginner level program began an exploration of goals and plans (intermediate level structures) relevant to the task-environment concept being explored. Buds in the intermediate level program began an exploration of themes (advanced level structures) in relation to cases already experienced in connection with a main goal (see Figure 1, intermediate level computer program structure). This theme bud is the "Adult Assumptions and Goals" portion of the intermediate level tree. The exploration of themes at this level was less extensive and less in depth than that included in the

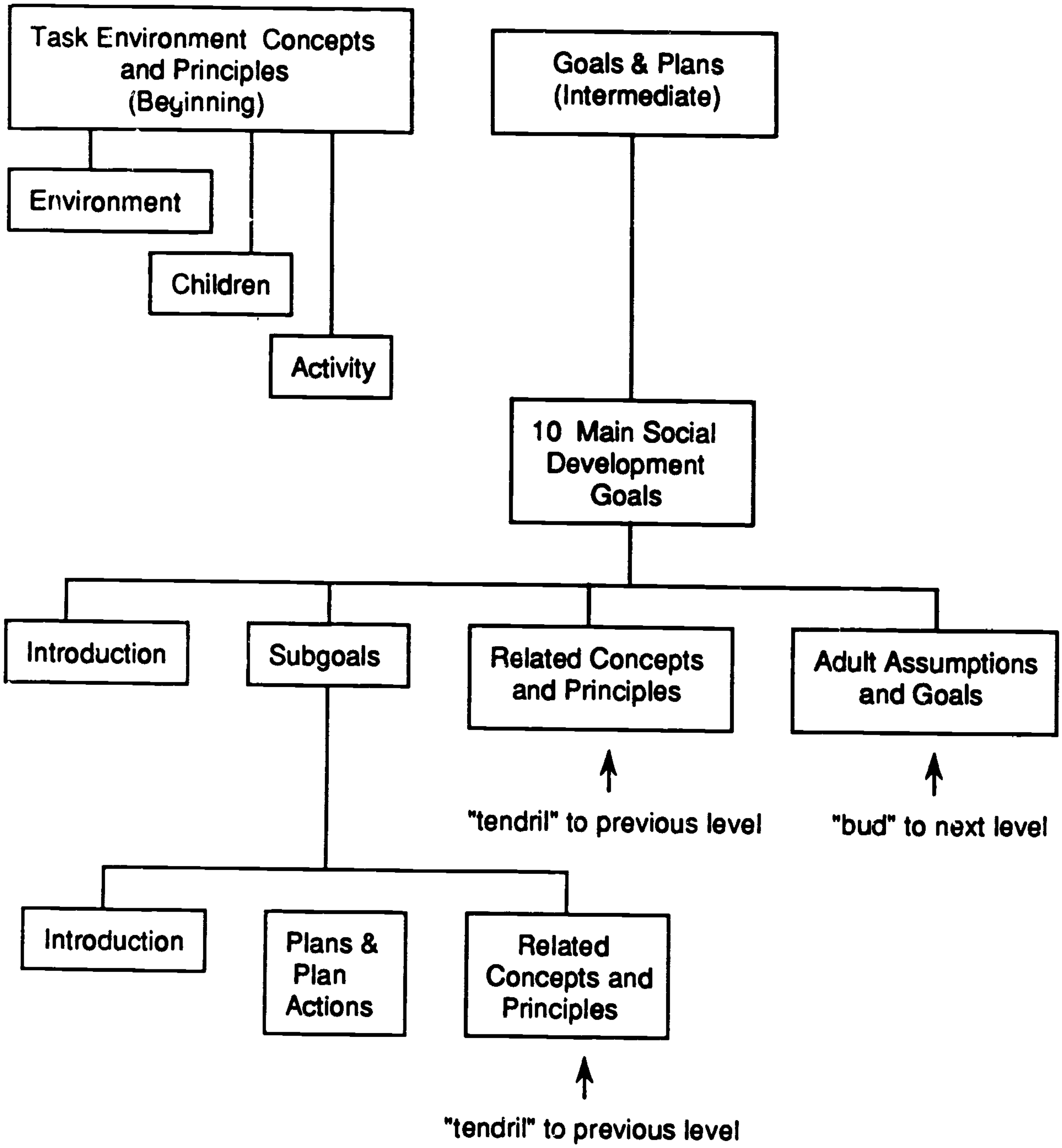


Figure 1. Structure of computer program for beginning and intermediate levels.

advanced level learning environment. Likewise, the exploration of goals and plans initiated in the beginning level program "bud" was less extensive and less in depth than that included in the intermediate level learning environment.

A tendril "reaches back" into the previous level and provides a linkage between the level the learner has completed and the level of the program currently being experienced. A tendril "pulls" previous learning along and embeds it within current learning. The intermediate level tendril that hooks back into the beginning level is highlighted in Figure 1. This tendril is represented by the "Related Concepts and Principles" portion of the intermediate level program structure. This tendril routed the learner to beginning level task-environment-focused knowledge that was relevant to the goal or plan being explored in the intermediate level learning environment. The primary objective in such backward routing is the linking and embedding of prior knowledge in newly developing and more advanced knowledge structures rather than review of knowledge. Because the prior knowledge is experienced in a new way and in a new light, revisiting it is a new experience rather than a review of an experience one has already had.

Creating Forms and Patterns of Mediation

Once the tree structures, buds, tendrils, and knowledge strands or packages were determined, detailed development of the computer program could proceed. This involved creating the details of the tree structures, selecting and organizing content of knowledge strands, and identifying and incorporating relevant video segments. It also involved developing the mediation to be provided by the computer as learners experienced the scenarios.

A conscious attempt was made to vary the form of mediation provided by the computer so that learners' experiences in the learning environment did not become routine. While the extent to which the video could be varied was limited (the disc only held one hour's worth of scenarios), the form of mediation had fewer limitations. Forms of mediation used included (a) asking learners (in advance of watching a scene) to look for specific things, (b) posing open-ended questions after learners saw a scene, (c) combining approaches (a) and (b), (d) asking learners to fill in charts as they watched scenes, (e) having learners share completed charts with each other after a scene was completed, (f) asking learners to compare their charts with one provided by the computer, (g) asking learners to choose options and then providing feedback on their choices, (h) giving learners opportunities to practice certain actions at specific points, and (i) giving learners opportunities to determine the points at which certain actions should occur.

Creating the Advanced, Theme-Development Level

A form was created for the advanced level of the learning environment that was quite different from that of the beginning and intermediate levels. The advanced level used a limited computer program which functioned only to drive the video-disc player. Learning was not mediated by the computer but rather by a series of written packets which asked open-ended questions which focused initially on a set of video scenes involving the same adult and then moved to reflections on personal experiences and personal patterns of goals, assumptions, and beliefs. The computerized video-disc-based learning environment was still important in this level because it allowed the video segments to be grouped in ways that were different from previous groupings and also gave learners control and the opportunity to explore additional groupings. In the advanced level, all the video segments on the entire disc were grouped on the basis of which adult was in the scene. All segments with the same adult were grouped together to facilitate discovery of the themes underlying the adult's pattern of actions across situations. The packets provided instructions and guided learners' exploration of the video segments from the perspectives of assumptions, beliefs, and priorities. Tendrils at this level reached back to the intermediate level goal-action focus, but did so in relation to discovering or considering possible sources of the goals.

A second segment of the advanced level focused on a different level and type of case analysis. This portion of the advanced level was intended to (a) address the range-of-experience principle, (b) continue the development of general themes relevant to a wide range of cases in different contexts and situations involving adults and children, and (c) develop "case-based" knowledge of specific cases indexed by themes. Neither the computer nor the video disc was needed for this level of the learning environment. Instead, a series of video-taped situations were identified as appropriate for exposing students to cases in a less-controlled order, an order that is typical of the way experiences are encountered in the real world and which makes detection of patterns in them so difficult when theme-level knowledge has not yet been developed. The structure of the entire prototype is presented in Figure 2, including the beginning, intermediate, and advanced levels.

## Learning Environment Hardware and Software

An IBM InfoWindow System was used for the parts of the prototype learning environment requiring computer mediation and the video disc. The computer program was written in Turbo Pascal, Version 4, and required DOS 3.1 or higher and 640K of RAM. The program was developed for an InfoWindow System run by a PS/2 computer, Model 30 or higher, and is believed to be also operable on an AT Model computer

## Review Processes and Pilot-Testing

Plans for, and development of, the prototype learning environment were reviewed regularly by a panel of experienced, expert practitioners in the knowledge domain. The prototype learning environment was pilot-tested twice as it was being completed. The first pilot test occurred early in

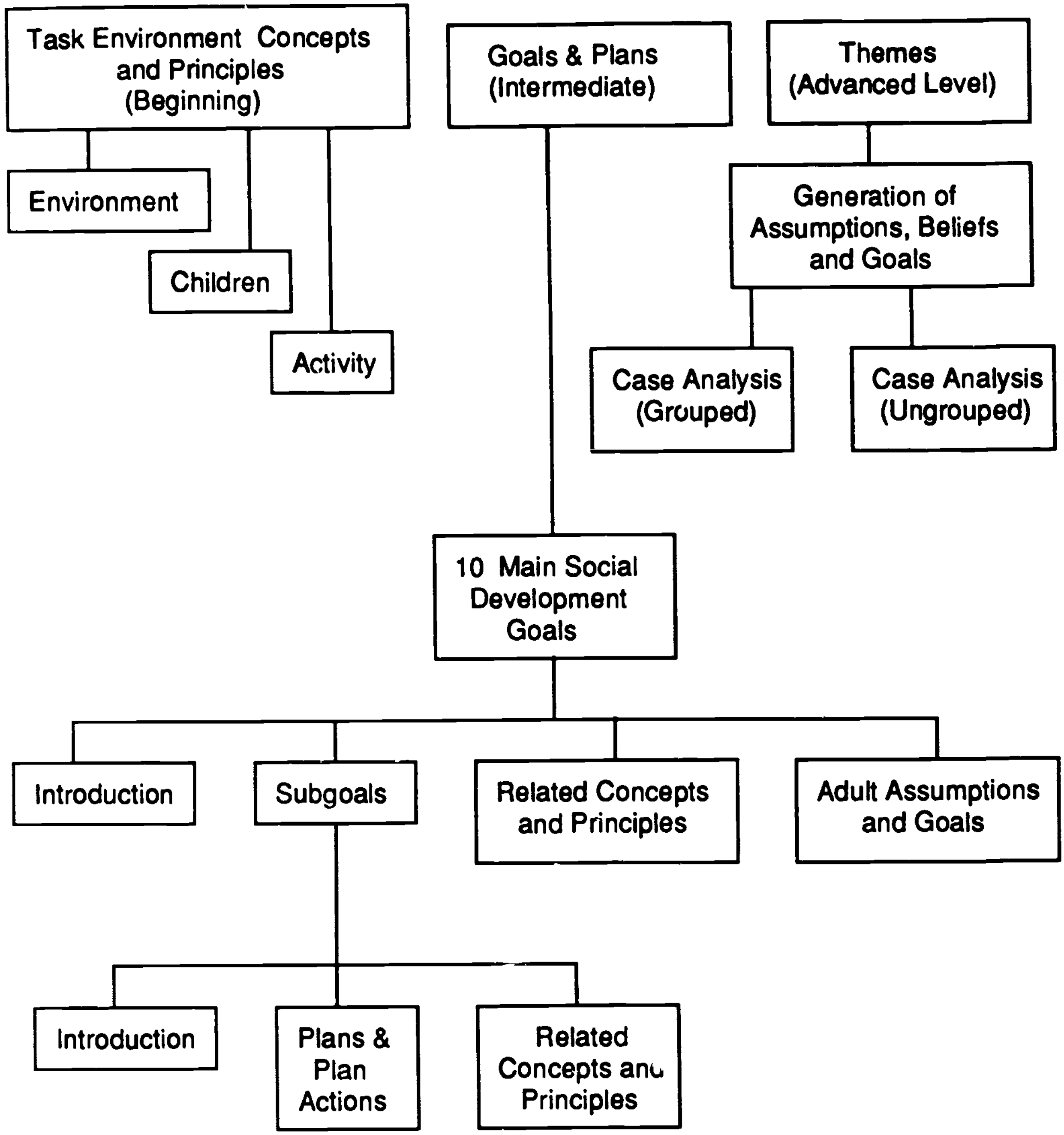


Figure 2. St-ucture of learning environment supporting development of beginning, intermediate, and advanced knowledge structures and thinking processes.

development and was intended to determine learners' general reactions to the learning environment, as well as to obtain data that would reveal if learners at various levels could be differentiated by their responses to the scenarios. The results of this test indicated that the 19 learners who were involved reacted positively to the learning environment and quickly adjusted to the technology which was new to almost all of them. Furthermore, the learners could be differentiated in terms of their learning levels on the basis of their responses to the scenarios. The results of this initial test are reported in Volume I (Thomas & Englund, 1989).

The second pilot test focused on the intermediate level of the program, which was the portion of the program that was computerized first. Since this level had both tendrils reaching back to the beginning level and buds extending to the advanced level, it was a useful level on which to obtain a preliminary test of design concepts underlying all three levels of the learning environment and to provide input to the further development and computerization of these levels. This second pilot test is reported in Chapter 4. This second pilot test also was a preliminary exploration of the effectiveness of the intermediate level of the learning environment in facilitating development of the kinds of knowledge structures and knowledge-thinking-process interactions described in Chapter 2, in Tables 1 and 2, and in the Appendix.

# CHAPTER 4

## EVALUATION OF INSTRUCTIONAL PROTOTYPE: INTERMEDIATE LEVEL

A computer-based video-disc learning environment was developed based on the instructional design model described in Chapter 3. This instructional prototype was conceptualized as having three levels:

1. A beginning level focused on concepts and principles regarding child development; on concepts and principles regarding physical, social, contextual, and activity aspects of task environments involving children; and on setting the stage for linking these to plans and goals for supporting children's social development.
2. An intermediate level focused on the development of plan and goal structures, on embedding concepts and principles from the beginning level within these structures, and on setting the stage for linking goals to themes.
3. An advanced level focused on the development of themes, case-based knowledge, and the formation of links between specific cases and the knowledge structures.

The design for each of the levels was structured to criss-cross the landscape of concepts relevant to supporting children's social development. Knowledge strands to be embedded in the level one (beginner) and level two (intermediate) computer programs were identified. The computer program and knowledge strands for level two were developed. Level two is the portion of the instructional prototype that was tested in the evaluation reported here.

### *Evaluation Design*

The evaluation design was developed to determine the effectiveness of the computer-based video-disc learning environment in facilitating development of the types of knowledge structures reflected in the knowledge domain (see Volume I, Thomas & Englund, 1989) and the knowledge-process interactions reflected in Tables 1 and 2 in this publication. While information about students' experiences with the learning environment relevant to revising and refining it was also obtained, that information is not reported here since this publication focuses on the effectiveness portion of the evaluation.

Three methods of assessment were used in the effectiveness evaluation. The first was an assessment approach developed in an earlier phase of the Higher Order Thinking Research Program at the Minnesota Research and Development Center (Thomas, 1988a). This approach, known as a Tailored Response Test (TRT), had been designed to test the application of knowledge in making judgments regarding adult actions in situations relevant to the social development of young children. The TRT had been previously tested with various types of learners including high school students, technical college students, associate degree students, baccalaureate degree students, and adult education students. The TRT contains nine video-taped vignettes of adults and children, and a written paragraph discussing each vignette. Individuals are asked to watch each vignette and then to edit the paragraph. Editing involves crossing out words, phrases, or sentences until the paragraph reflects the person's judgment about the situation. The earlier study involved 127 learners similar to those in the present study. Statistical analyses of that study's data revealed internal consistency coefficients on the nine paragraphs that ranged from .70 to .91, as well as concurrent validity data that supported the TRT's validity (Thomas, 1988a).

The other two assessment strategies were developed specifically for the learning environment. Their use in this study constitutes a pilot-test of these approaches. The first of these consisted of a diagnostic test designed to indicate which level of the program was most appropriate for a given learner. This test involved viewing three scenes on the video disc that were similar in their surface features but different in their deeper features. The similarities in surface features included the following: all involved (a) lunch scenes, (b) similar menus, (c) preschool children, and (d) a group of children and one adult sitting at a table. The deeper features which differed among the scenes included (a) the degree to which children were engaged as participants in lunch-related tasks such as getting and passing food, (b) the amount and nature of conversation among the children and between the adult and the children, and (c) the roles taken by the adult and the children in the situation. It was expected that individuals at intermediate or advanced levels of development in the knowledge domain would detect deeper features and that individuals at a beginning level would focus their attention on surface features. Empirically determining the diagnostic-test-score levels which would differentiate beginning, intermediate, and advanced level learners was one of the goals of this evaluation. In addition to detecting learners' levels at the beginning of their experience with the learning environment, a second function of the diagnostic test was to determine learning gains through pre- and post-test comparisons. Since the diagnostic test involved scenes used in the learning environment for other purposes, it was viewed as involving less transfer of learning than the TRT, which involved scenes and people that were different from those used in the learning environment.

A third assessment approach, identified as scenario analysis, involved learners in watching a brief scene that was unfamiliar to them and writing an open-ended interpretation of the scene. Written scenario analyses were content analyzed for the types of knowledge structures they reflected (e.g., environment, plans, goals, themes), and for the degree of development that was reflected within the knowledge-structure type. The latter dimension was indicated by the level of abstraction reflected in the concepts used and by the degree to which children or adults were the central focus according to the domain-development progression (reflected generally in Table 2 and specifically in the Appendix).

The descriptions included in the Appendix were used as the theory-based coding documentation for this content analysis. The detail of the Appendix is summarized in Table 3. Table 3 provides a description of the layers of development in relation to the types of knowledge structures. Links among the types of knowledge structures were also noted in the content analysis and interpreted as evidence of integration within and among the knowledge-structure types. Links were scored according to a procedure developed by Novak and Gowin (1984). Within-cell links were assigned a score of 1 (see Table 3). Within-column links (links across layers within the same knowledge-structure type) were assigned a score of 5. Links within rows and links crossing rows and layers (links running horizontally and diagonally on Table 3) were assigned a score of 10. A graphing procedure was developed which provided a visual, qualitative picture of an individual's thought and knowledge.

*Procedures*

All learners who participated in the test of the learning environment were volunteers. Thirty-two learners of varying background within the knowledge domain experienced the learning environment for between 10 and 30 hours in groups of two to four people. The reasons for having learners experience the learning environment in groups rather than as individuals were both theory-based and practical in nature. Theoretical reasons focused on the opportunities for deep processing and mediation of concepts and issues that discussion of them is likely to provide. Deep processing occurs when more time is spent thinking about a concept and the concept is linked to a range of other ideas. Dialectic thinking occurs when one confronts differing views. The potential for mediation supportive of learning is especially enhanced when group members vary somewhat, but not too much, in their levels of development within a domain. Higher-level learners are a likely source of learning-supporting mediation for lower-level learners. Practical reasons for grouping learners were related to access to the learning environment, since equipment comprising only one learning environment was all that was available and all learners had to use this one environment. Practical reasons also governed how learner groups were constituted. In some cases, practical considerations outweighed the mediation reasons described above, since individuals' schedules were a primary determinant of when they were available. Furthermore, some groups came from the same work environment with the intent of being grouped together.

Participants in the evaluation were pre-tested during their first session and post-tested during their final session of participation. All three assessment materials described earlier were used as pre- and post-tests. The three pre- and post-assessments took approximately 4 to 5 hours to administer. Consequently, individuals whose participation was limited to 10 hours experienced approximately 5 to 6 hours of instruction, 20-hour participants experienced approximately 15 to 16 hours of instruction, 14- to 16-hour participants experienced approximately 9 or 10 to 11 or 12 hours of instruction, and 30-hour

Table 3

Developmental Progression in the Knowledge Domain of Supporting Children's Social Development

| | Types of Knowledge Structures | | | | | |
|---|---|---|---|---|---|---|
| Development layer | Environment features (Setting, children, activities) | Adult actions (Moves of adult within task environment) | Plans (Actions that can be used to achieve goals) | Goals (Motives, intentions) | Priorities (Importance of goals) | Themes (Perspectives, beliefs, assumptions) |
| 1 | Specific instances of task-environment elements | Specific-action instances | Specific-action instance possibilities | Adult-focused motives, intentions | Importance placed on adult-focused goals | Views of children, adults, situation in a specific context |
| 2 | Sense-apprehended concepts, categories of task-environment elements | Sense-apprehended action concepts, categories | Action possibilities in terms of sense-apprehended concepts, categories | Situation-specific, child-focused motives, intentions | Importance placed on child-focused goals related to group needs, less developmentally significant goals | Views of children, adults, situations in general--across contexts |
| 3 | Inferred, relational concepts and categories of task-environment elements | Inferred action concepts, categories | Action possibilities in terms of inferred action concepts, categories | General child-focused motives, intentions in terms of specific areas of development | Importance placed on child-focused goals related to individual needs, developmentally significant goals | Views of qualities of relationships between adults and children; pervasive, general qualities that characterize, summarize situations |
| 4 | Theoretical concepts, categories of task-environment elements | Action complexes, systems | Action possibilities in terms of action complexes, systems | General child-focused motives, intentions in terms of broad areas of development | Importance placed on child-focused goals related to broad, theoretical areas of development | Views of consequences or impact of goals on children's development and learning |

participants experienced approximately 25 to 26 hours of instruction. One of the 30-hour groups experienced a few less instructional hours since they provided considerable input into the development of the intermediate level bud structure and materials.

### *Findings and Discussion*

Of the thirty-three learners who took the pre-tests, thirty-two completed the number of hours of instruction they contracted for and took the post-tests. In one case, a person who began participation with another individual finished on her own when her partner's schedule changed and the two could not continue working together.

#### Profile of Participants

A demographic profile of the participants is provided in Table 4 and Table 5. Table 4 reports the gender, age, and highest level of post-high school education completed by participants in the learning environment evaluation. Most were female, between 23 and 40 years of age, and half had completed some level of higher education.

Table 4

Participants Completing Pre-Assessments: Gender, Age, and Highest Level of Post-High School Education Completed (N = 33)

| | | N | % |
|---|---|---|---|
| Gender | Female | 30 | 91 |
| | Male | 3 | 9 |
| Age | 17-22 | 4 | 12 |
| | 23-30 | 7 | 21 |
| | 31-40 | 12 | 36 |
| | 41-50 | 5 | 15 |
| | 51-60 | 4 | 12 |
| | No response | 1 | 3 |
| Highest Level of Post-High School Education Completed | | | |
| | One year post-high school | 1 | 3 |
| | Associate degree | 2 | 6 |
| | Baccalaureate degree | 6 | 18 |
| | Master's degree | 7 | 21 |

Table 5

Current Student Status of Participants in Learning Environment Evaluation

| Current student status | N | Level within current student status | N |
|---|---|---|---|
| Not a student | 3 | --- | -- |
| High school | 6* | Senior | 5 |
| | | Junior | 1 |
| Technical college program student | 4* | Second year | 1 |
| | | Licensure | 3 |
| Associate degree program student | 1 | Second year | 1 |
| Undergraduate in baccalaureate degree program | 6 | Senior | 5 |
| | | Junior | 1 |
| Continuing education student | 3 | --- | -- |
| Post-baccalaureate program student | 10 | Doctoral | 5 |
| | | Masters | 5 |

* Two high school students were enrolled in technical college programs; thus, the total number of technical college students was six rather than four.

Table 5 indicates that most participants were students enrolled in an educational program of some type. The types of programs in which participants were enrolled varied considerably, from a high school program to a doctoral program. The distribution of individuals across these various educational levels is shown in Table 5.

The majors of individuals who were enrolled in postsecondary programs are reported in Table 6.

Table 6

Majors in Past and Present Post-Secondary Programs of Enrollment by Participants

| Major | N |
|---|---|
| **Major in program of current enrollment** | |
| Technical college program | |
| Child development | 4 |
| Associate degree program | |
| Human services (child dev. concentration) | 1 |
| Baccalaureate program | |
| Child psychology | 3 |
| Home economics education | 3 |
| Math | 1 |
| Sociology | 1 |
| Master's program | |
| Home economics education | 5 |
| Early education/Special education | 1 |
| Doctoral program | |
| Family life education | 4 |
| Ministry, church growth | 1 |
| **Major in previously completed program(s)** | |
| Two-year post-high school program (nondegree) | |
| Bible | 1 |
| Baccalaureate program | |
| Child psychology | 1 |
| Elementary education | 2 |
| Family relationships | 1 |
| Home economics education | 1 |
| Physical education | 1 |
| Psychology | 2 |
| Social sciences | 1 |
| Master's program | |
| Home economics/Home economics education | 6 |
| Social Work | 1 |
| Theology | 1 |

## Pre-Assessments

One question which existed concerning the three approaches to assessment was the degree to which they overlapped, or measured the same thing, and the degree to which they measured different constructs. Furthermore, since learners had widely varying levels of educational background and experience with children, some were likely to be beginners, some intermediates, and some advanced learners in the knowledge domain. If this was the case, did the assessments operate differently for these groups? Was the diagnostic able to identify individuals of differing levels of domain-knowledge development? Table 7 presents pre-test score data on the three assessments for all participants who completed both the pre- and post-measures.

Table 7

Pre-Test Scores on Tailored Response Test, Diagnostic Test, and Scenario Analysis Links

| Test | N | Minimum | Maximum | Mean | Median | S.D. |
|---|---|---|---|---|---|---|
| TRT | 32 | 140 | 249 | 195 | 190 | 26.8 |
| Diagnostic | 32 | -5 | 15 | 6 | 6 | 5.5 |
| Scenario analysis links | 31 | 10 | 166 | 56 | 51 | 35.2 |

The scores on both the TRT and the diagnostic were closer to the top than to the bottom of the possible ranges. The possible range in scores on the TRT was 0 to 254. Consequently, a score range from 140 to 249 indicates that individuals scored in the upper half of the possible score range and that some were very close to a perfect score on this test. The mean of 195 and median of 190 further suggest that this group scored in the upper ranges of the possible scores on this test. These score patterns introduce the possibility that score ceilings may have been operating on this test for some members of the group. Similar patterns are suggested in the diagnostic test data. This test had a possible range from a low of -16 to a high of +18. High scores of 15 and a mean and median of 6 points suggest that the group scored toward the high end of the possible range. Since the scenario analysis was open-ended, there was no ceiling for this assessment.

Possible relationships between the three pre-test assessments were investigated by correlating the pre-scores. Since the number of participants was small, correlations should be interpreted with caution. The resulting coefficients are reported in Table 8.

Table 8

Intercorrelations Among Pre-Test Scores

| Pre-test | TRT (N = 32) | Diagnostic (N = 32) | Scenario analysis links (N = 31) |
|---|---|---|---|
| TRT | 1.00 | - 0.02 | 0.33 |
| Diagnostic | | 1.00 | -0.12 |
| Scenario analysis links | | | 1.00 |

The coefficients in Table 8 indicate that scores on the diagnostic are unrelated to TRT scores and reveal a low, negative correlation with the scenario-analysis-links scores. The TRT and the scenario-analysis-links score, however, bear a moderate, positive relationship to each other, which is significant at the .10, but not at the .05 level (df = 29). Thus, it would seem that the diagnostic and the TRT are tapping different constructs and that there may be some overlap in the constructs measured by the TRT and the scenario-analysis-links scores.

In addition to the links scores, a second type of analysis was applied to the scenario-analysis data. This analysis examined the types of knowledge structures reflected in the written analyses of the video-taped scene. Table 3 was applied to the written analyses as a grid. The content of each written analysis was segmented and coded using the documentation in the Appendix. A segment represented a thought unit categorizable within the knowledge structure types and layers represented in Table 3 and described in more detail in the Appendix. Selected diagrams developed during the analysis are presented in Figures 3, 5, and 7 and provide a sense of the qualitative nature of this data. Each point in these figures represents a thought-unit segment as defined above. The types of links described in the evaluation design section of this chapter in connection with their scoring are represented in the diagrams according to the legend provided with the figures.

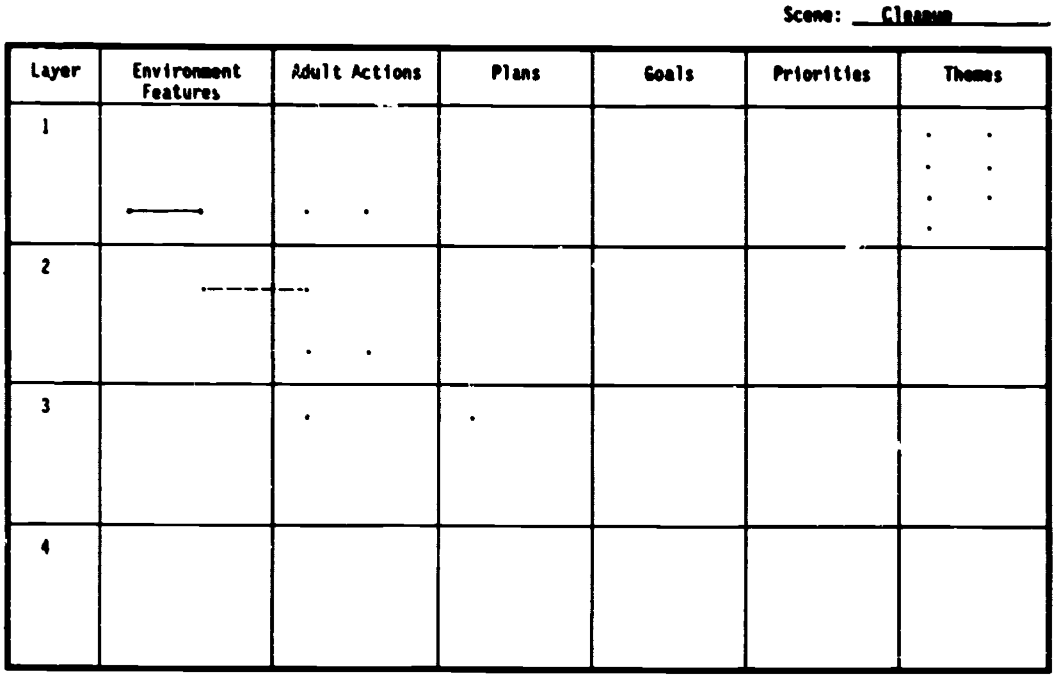


Figure 3. Scenario Analysis - Pre-assessment: Learner A.

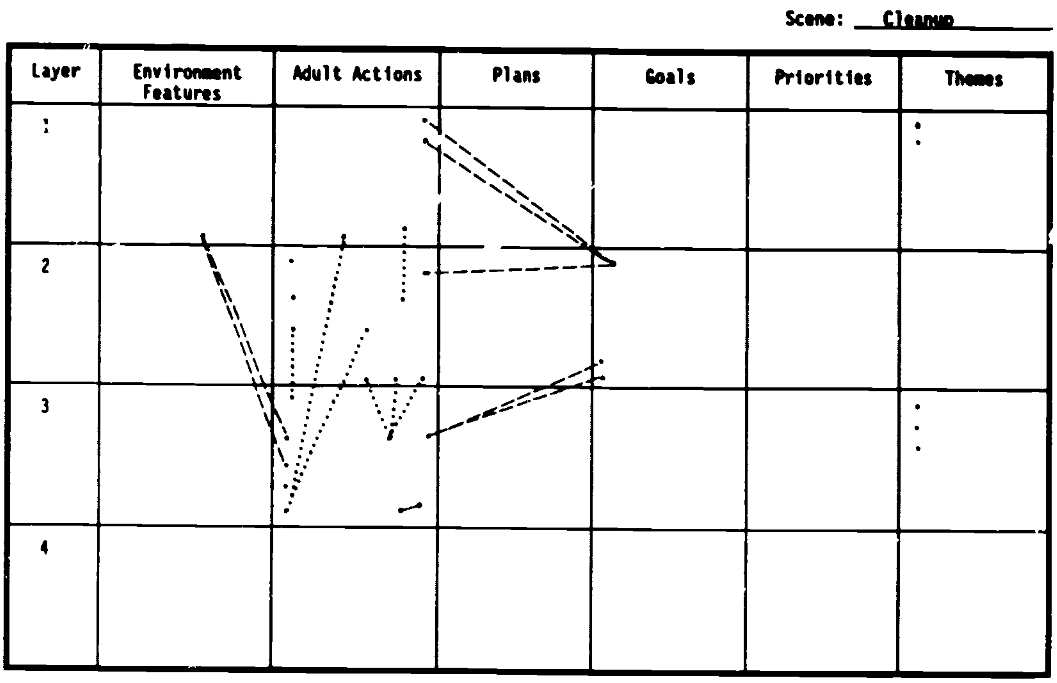


Figure 4. Scenario Analysis - Post-assessment: Learner A.

Legend

| | |
|---|---|
| . | thought unit |
| ___ | links within knowledge-structure type and layer |
| ........ | links within knowledge-structure ty, e (columns) and across layers |
| - - - | links across knowledge-structure type (columns) |

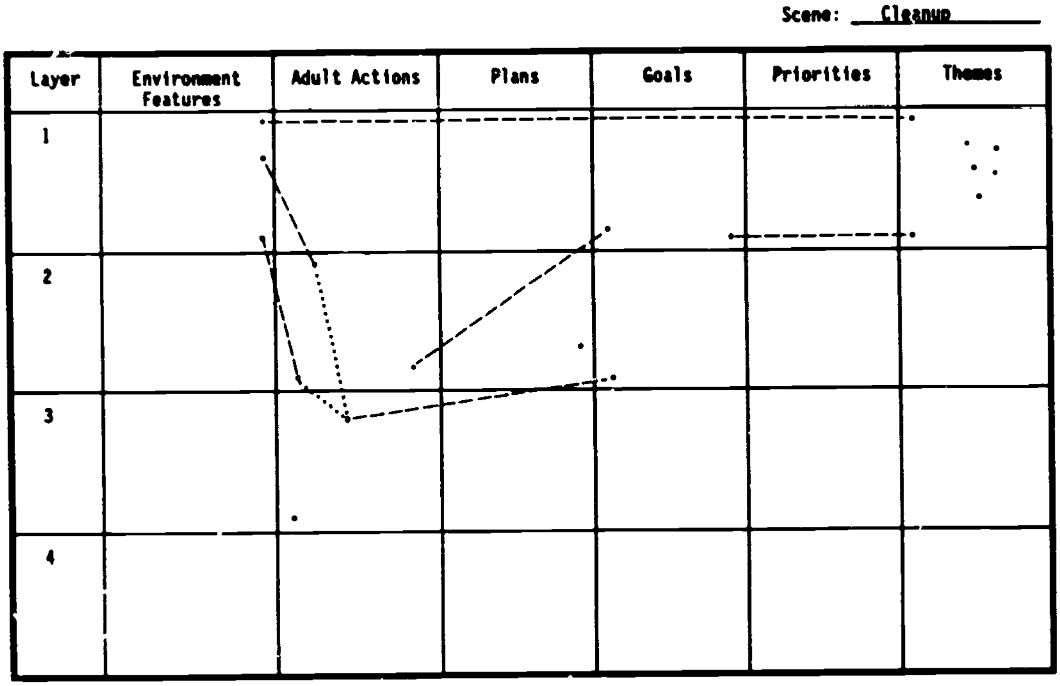


Figure 5. Scenario Analysis - Pre-assessment: Learner B.

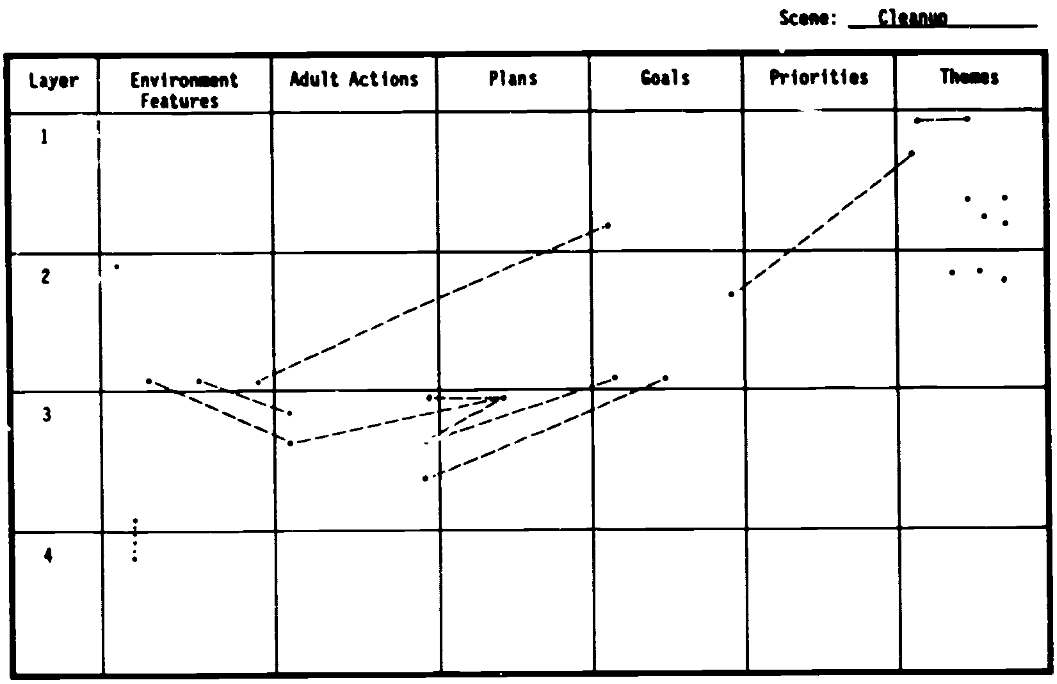


Figure 6. Scenario Analysis - Post-assessment Learner B.

Legend

thought unit

___ links within knowledge-structure type and layer

........ links within knowledge-structure type (columns) and across layers

- - - links across knowledge-structure type (columns)

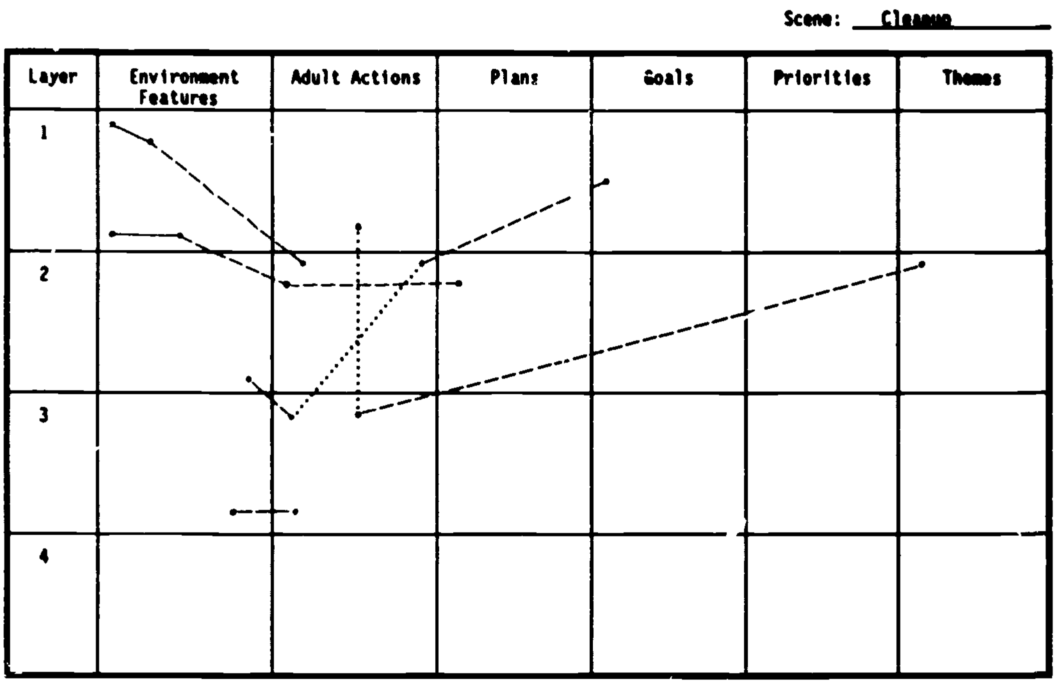


Figure 7. Scenario Analysis - Pre-assessment: Learner C.

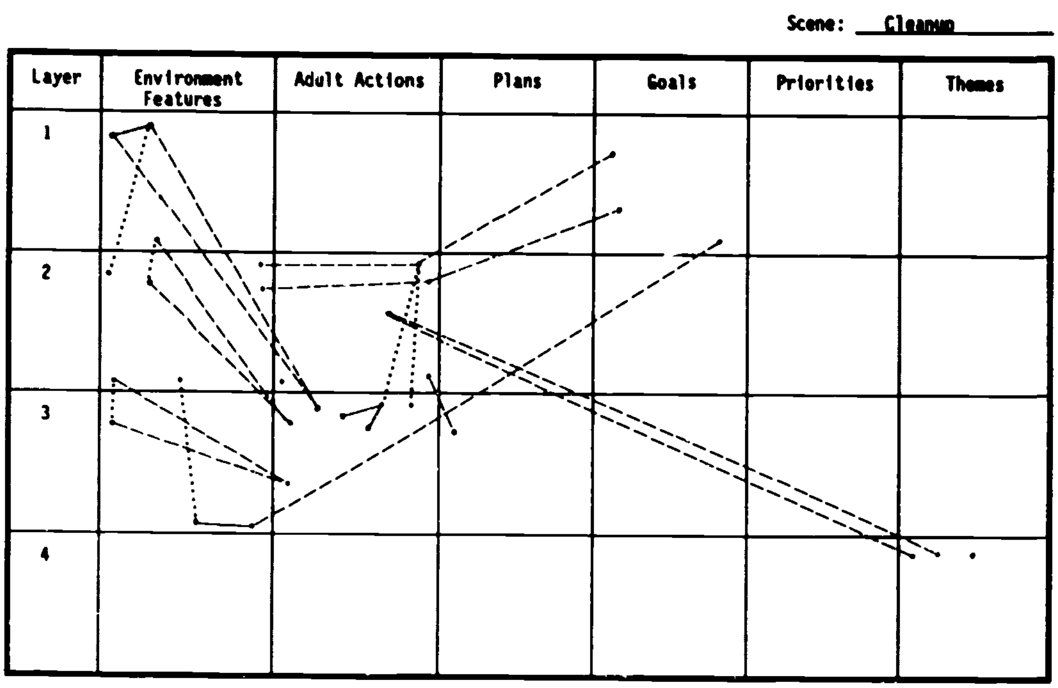


Figure 8. Scenario Analysis - Post-assessment: Learner C.

Legend

- . thought unit
- ____ links within knowledge-structure type and layer
- ........ links within knowledge-structure type (columns) and across layers
- - - - links across knowledge-structure type (columns)

The independence of the TRT and the diagnostic reflected in Table 8 is useful information. The TRT was developed to assess the application of knowledge in making judgments about the actions people take. TRT scores are believed to reflect degree of knowledge development within the knowledge domain of supporting children's social development and ability to connect domain knowledge to specific cases. The diagnostic is a simpler and more straightforward device intended to tap the degree to which a person's focus is limited to surface-level sensory information or extends to deeper features that require more knowledge and interpretation to detect. Even though the total distributions for these two measures appear to be independent, it is possible that a curvilinear relationship may exist in which positive relationships exist at some points on the distributions and negative relationships exist at other points. The possibility also exists that the scenario-analysis-links scores may also be related to the diagnostic in a curvilinear fashion. The present data are too limited to allow the kind of exploration that could shed light on these possibilities.

The moderate, but not quite significant, relationship between the TRT and the scenario-analysis-links scores suggests that a significant relationship might be found with a larger number of participants. Furthermore, these data suggest that the TRT may tap knowledge development and integration across the spectrum of knowledge-structure types, a function for which it was intended when it was developed.

Comparison of Pre- and Post-Assessments

After instruction, the same assessments that were administered as pre-assessments were re-administered. Differences in pre- and post-assessment means were compared using the t-test for correlated data. Means for pre- and post-assessments are presented in Table 9 along with t-test values and one-tailed $p$ values.

The data in Table 9 indicate significant increases in the means on the TRT and the diagnostic. The scenario-analysis-links score means increased, but the pre- and post-differences did not attain a high enough probability level to be considered beyond the realm of chance. This may be due to the exploratory nature of this measure and a need for additional development. Patterns in the data presented in Table 9 suggest that learners' abilities to see more deeply into situations, to see their deep features and to apply more domain-relevant knowledge in making judgments about situations increased from pre- to post-testing. While the learning environment likely had a significant role in these changes, it should be noted that, for some of the learners, other relevant learning experiences were also occurring outside the learning environment. For example, several learners were enrolled in child development, parenting, or early-education classes during the period in which they experienced the learning environment. It was not possible to isolate the possible effects of such other experiences and

Table 9

Comparison of Pre- and Post-Assessment Score Means on Tailored Response Test, Diagnostic, and Scenario Analysis Links

| Test | Number of paired observations | Mean | S. D. | t | One-tailed p | df |
|---|---|---|---|---|---|---|
| TRT | 32 | | | | | |
| Pre | | 195.0 | 26.8 | -2.14 | .025 | 31 |
| Post | | 203.0 | 24.2 | | | |
| Diagnostic | 32 | | | | | |
| Pre | | 6.3 | 5.5 | -2.68 | .010 | 31 |
| Post | | 9.5 | 7.0 | | | |
| Scenario analysis links | 31 | | | | | |
| Pre | | 56.0 | 35.2 | -1.30 | .10 | 30 |
| Post | | 66.0 | 55.3 | | | |

variables that may also have affected assessment scores. An experimental design would be needed in order to obtain such information.

Comparison of Pre- and Post-Assessments by Instructional Hours

Table 10 reports pre- and post-means for subgroups experiencing different numbers of instructional hours. Differences in these means were not tested for significance because of the small numbers within each subgroup.

Table 10 indicates that, in general, means on assessments increased from pre- to post-administrations for the subgroups. There were three exceptions to this pattern. For the TRT, the 10-hour group's post-mean remained virtually unchanged compared to the pre-mean. Interestingly, the range in TRT scores for this group also remained very stable from pre- to post-testing. For the

Table 10

Comparison of Pre- and Post-Means on TRT, Diagnostic, and Scenario-Analysis-Links Scores by Number of Instructional Hours

| Test and hours of instruction | Number of paired observations | Pre | | | Post | | |
|---|---|---|---|---|---|---|---|
| | | Mean | Range | S. D. | Mean | Range | S. D. |
| TRT | | | | | | | |
| 30 hrs | 13 | 196 | 151-249 | 29.2 | 207 | 173-246 | 21.9 |
| 20 hrs | 4 | 204 | 181-225 | 22.5 | 215 | 183-236 | 22.6 |
| 14-16 hrs | 5 | 186 | 140-224 | 35.1 | 197 | 137-222 | 34.6 |
| 10 hrs | 10 | 195 | 164-246 | 23.0 | 196 | 164-240 | 22.8 |
| Diagnostic | | | | | | | |
| 30 hrs | 13 | 5.8 | -5 - 12 | 5.0 | 8.5 | 0 - 17 | 6.3 |
| 20 hrs | 4 | 9.3 | 4 - 14 | 5.5 | 14.8 | 12 - 17 | 2.6 |
| 14-16 hrs | 5 | 6.8 | -3 - 11 | 5.8 | 6.4 | -5 - 16 | 8.9 |
| 10 hrs | 10 | 5.6 | -3 - 15 | 6.5 | 10.1 | -4 - 17 | 7.5 |
| Scenario analysis links | | | | | | | |
| 30 hrs | 12 | 59.6 | 10 - 166 | 43.8 | 54.9 | 0 - 168 | 54.1 |
| 20 hrs | 3 | 45.5 | 11 - 75 | 32.3 | 92.8 | 40 - 139 | 41.4 |
| 14-16 hrs | 4 | 38.6 | 20 - 75 | 22.3 | 51.6 | 20 - 90 | 26.2 |
| 10 hrs | 10 | 65.1 | 20 - 110 | 29.8 | 80.5 | 15 - 260 | 70.0 |

diagnostic, the post-mean for the 14- to 16-hour group went down very slightly. The range on the diagnostic widened from pre- to post-testing for this group, especially at the upper end. On the scenario analysis, the 30-hour-group mean went down slightly. The range widened at the lower end. The other nine means increased from the pre- to the post-assessment.

A second aspect of Table 10 is of interest. This is the pattern of score ranges for the various instructional-hour groups. For the most part, each instructional-hour subgroup included individuals ranging widely in their pre- and post-scores. This would suggest that each instructional-hours group included individuals who were at a level of development appropriate for the intermediate level of instruction they received, as well as individuals who were beyond the intermediate level and those who were not yet at the intermediate level. The score pattern for the 20-hour group varied sufficiently from that for the other groups to suggest that these individuals may, as a group, have been most optimally matched in their development to the level of instruction. On the TRT pre-assessment, this group's score range was the narrowest of all the groups. This was also true for their post-TRT scores. Both their pre- and post-TRT means were the highest of all the groups. On the diagnostic, the 20-hour group had the highest pre-mean and the highest post-mean, and made the largest gain. The pattern for the scenario-links scores revealed that this group also had the largest gain of all the groups on that assessment.

The small numbers in the 20-hour and 14- to 16-hour instructional groups make it difficult to draw conclusive inferences about patterns in the data. However, if the 20-hour group was comprised of individuals whose developmental levels were especially appropriate for the intermediate level of instruction, it would be reasonable to hypothesize that pre-diagnostic scores reflected by this group (a range of 4 to 14) and TRT pre-scores attained by this group (an approximate range of 180 to 225) indicate a level of development appropriate for the intermediate level learning environment. To test the plausibility of this hypothesis, all individuals whose pre-scores fell in these ranges were identified. Using a one-way ANOVA with instructional hours as the factor, score-change means on the diagnostic and the TRT for each instructional hours group were compared. While none of the f values attained significance, those closest to doing so were attained for the diagnostic when individuals having pre-diagnostic scores between 3 or 4 and 14 or 15 were included in the analysis. The results of this analysis for the TRT did not disconfirm the suggested range of 180 to 220 on the pre-TRT as the band appropriate for intermediate level instruction, but the f values were less strong than for the diagnostic.

The data set is too small when factored into instructional-hours groups to be more than suggestive, but these analyses do offer helpful clues that can be further explored. The data patterns in Table 10 are suggestive of the importance of being able to identify the developmental level of learners with respect to the knowledge domain so that an appropriate level of instruction can be provided. The number of hours of instruction was not, in itself, predictive of learning. When the analysis of instructional hours was conducted within pre-score assessment ranges as described above, the relationships between instructional hours and score changes became much stronger.

From a theoretical standpoint, the match between the learner's developmental level and the level of instruction would be expected to be a strong factor in predicting the amount of learning. However, there is an alternative explanation for the patterns that are reflected in Table 10. The 20-hour group, as a very small group, may be more homogeneous and thus, individuals in it may be more similarly affected by the learning environment. The other, larger, more diverse groups may not exhibit such patterns because of their diversity. This explanation may not entirely account for the patterns however. A similarly small group having a few less hours of instruction (14 to 16 hours) did not display the distinctively different patterns that the 20-hour group did. The score patterns in this second small group were more like those in the larger groups than they were like the 20-hour-group's patterns. While the 20-hour-group's homogeneity may seem important on the surface, it is more likely that it is the match between the 20-hour-group's level of development and the intermediate level learning environment that is the crucial factor. In other words, had the 20-hour group been homogeneous in pre-scores, but fallen at the extreme-low or extreme-high ends of the pre-score ranges, it is likely that their patterns would not have reflected the increases apparent in Table 10.

Comparison of Qualitative Graphs

Post-data from the part of the scenario analysis that involved identifying and graphing knowledge structures and links among them represented in the written expressions are reflected for three selected individuals in Figures 4, 6, and 8 (see the documentation in the Appendix and note Table 3, which summarizes the Appendix). Comparison of post-graphs in Figures 4, 6, and 8 with the pre-graphs of the same individuals (Figures 3, 5, and 7, respectively) reveals an increase in (a) thought involving more advanced layers of development; (b) thought involving plans, goals and/or themes; and (c) expressed links among thoughts. Since the graphing procedure was newly developed for this test phase, the main focus of the analysis was on whether or not it revealed and aided understanding of the nature of cognitive changes that took place for individuals during the period of instruction. The graphs included in Figures 3 through 8 were judged to meet these goals. Since the graphs were intended as individual rather than group data, they were not summarized beyond the links scoring that has already been reported.

### *Summary*

The data reported and discussed in this chapter indicate change in pre- and post-assessments that reflect learning gains as learning was defined in this project. Learning in anticipated directions was reflected in both quantitative and qualitative assessments. Patterns of scores on the TRT and the diagnostic appear to be independent, suggesting that they are measuring different kinds of learning. The scenario analysis may tap yet additional dimensions of learning, dimensions that the data suggest are likely more similar to dimensions reflected by the TRT than those assessed by the diagnostic. It was also apparent that not all individuals' scores increased. It is hypothesized that those who did learn were at levels in their own development within the knowledge domain that matched the intermediate level of the learning environment, and that those whose scores and graphs did not reflect learning were at levels of development above and below an intermediate level.

# CHAPTER 5

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

*Summary*

History and Context Underlying the Research

The research reported in this document comprises a portion of the third phase of the Higher Order Thinking Research Program in the Minnesota Research and Development Center. The first phase in this program of research entailed developing an understanding of knowledge and thinking processes underlying competent practice in two contexts of interest in vocational education: Work contexts and family contexts. The second phase of research developed an approach to assessing application of knowledge to work situations and knowledge-thinking-process interactions. The present, third phase is focused on developing instruction to facilitate higher levels of thinking and to support learners in constructing knowledge that underlies such thinking. This third phase incorporated, built on, and extended research completed in phases one and two.

Purpose

The purpose of this research was to apply cognitive theory and research to the development of an instructional design model for vocational education that would address a range of changing conditions in the workplace and the family. More specifically, the intent was to develop an instructional design model that would (a) reflect the interests of vocational education in real-world work and family contexts and activities; (b) focus attention on the mental aspects underlying work or family activities; (c) address learning goals that include, but extend beyond, performance to underlying meanings; (d) reduce the separation of cognition from affective and psychomotor aspects of human activities; (e) prepare learners for the world as it currently exists, as well as the yet-to-be-determined world of the future; and (f) be reasonably practical for vocational education to implement in terms of effort and cost.

Objectives

Specific objectives of the research reported here were to (a) develop an instructional design model for teaching mental aspects underlying work and family activities in a context of rapid change and high technology, (b) test the instructional design model by developing a prototype instructional design for teaching mental aspects underlying activities within a domain relevant to vocational education, (c) develop materials required by the prototype instructional design, and (d) test the prototype instructional design for effectiveness in facilitating development of the mental aspects underlying activities within the selected domain.

Procedures

This research sought to develop and test an instructional design model to support learners' construction of knowledge. Four factors were identified as particularly significant in supporting learners' knowledge construction: (a) fidelity of the learning situation to the real world, (b) visualization, (c) range and depth of learners' experiences, and (d) mediation of learners' interpretations of their experiences. It was intended that knowledge constructed by learners have the following characteristics and functions: The ability to (a) integrate goals, intentions, and actions with features of the external world and domain-knowledge concepts and principles; (b) focus attention on deep-level features; (c) facilitate interpretations in terms of powerful, superordinate-level concepts and principles; and (d) support sensitivity to subtle but important variations among cases.

The instructional design model that was developed is presented in Chapter 3. A computer-based, video-disc learning environment was developed as a prototype instructional design based on the instructional design model in order to test the model. This instructional prototype was conceptualized as having three levels: (a) a beginning level focused on concepts and principles regarding task environments relevant to an identified knowledge domain; (b) an intermediate level focused on the development of goals and plans, and on embedding concepts and principles from the beginning level within them; and (c) an advanced level focused on the development of themes and case-based knowledge.

The intermediate level of the instructional prototype was tested in the evaluation reported here. This evaluation comprised the second pilot-test of the instructional prototype. The first, smaller-scale, initial tryout pilot test involved 19 learners and is reported in Volume I (Thomas & Englund, 1989). A purpose of the present evaluation, which involved 32 learners, was to determine the effectiveness of the intermediate level of the learning environment in facilitating the kinds of development described in Chapter 2, Chapter 3 (Tables 1 and 2), and in the Appendix.

## *Conclusions and Recommendations*

Effectiveness

Findings supported the effectiveness of the learning environment in elaborating, modifying, and reorganizing knowledge structures in ways that enhance capacities to detect deep-level features and to apply knowledge in making judgments regarding actions that fit a situation. This study's findings suggest that a computerized video-disc-based learning environment can facilitate higher levels of cognitive development if it is grounded in theories that focus on the nature of higher levels of thinking and on the nature of knowledge that supports such thinking.

The data suggest that, as anticipated, the intermediate level learning environment was most effective for individuals whose level of prior knowledge development was commensurate with that level of instruction. Although the participants involved in this study represented a wide range of levels of development in the knowledge domain, all experienced the level two, or intermediate, program. Thus, the group whose knowledge was at an appropriate level for the program was a subset of the total group, a subset that was too small for some types of data analysis that would have been helpful.

Assessments

The tryout of the diagnostic with a wide-ranging, mixed type of group was a necessary step in determining how it might work as a selection device in relation to learning-environment levels and as a measure of learning. The data from this investigation of the diagnostic will be used in making decisions about which level of the learning environment should be experienced by individuals on the basis of their diagnostic scores.

Both the TRT and the diagnostic appeared to be able to detect changes in capacities of learners who experienced the learning environment. While the role of the scenario analysis in relation to these other two measures is not fully defined at this point, the qualitative information in the graphs appears to provide helpful information about changes in specific characteristics of individuals' knowledge. The pre- and post-graphs of individuals' expressions contained in their analysis of a video-taped scene provide a visual picture of knowledge elaboration, modification, and reorganization. Such information is potentially useful in providing possible explanations regarding score patterns produced by other measures, especially the TRT, and in understanding the qualitative nature of cognitive changes that may occur as a consequence of experience with the learning environment. The graphing technique captured a richness in the data that makes it a promising approach to characterizing and understanding cognitive changes that more traditional, objective-test-type approaches to assessing learning have not addressed. Efforts to further refine the approach should be undertaken.

A crucial aspect of the design of the learning environment was the understanding and model of the knowledge domain that is reflected in Volume 1 of this series (Thomas & Englund, 1989). In the present publication, Table 3 (in Chapter 4) and the Appendix represent extensions of the knowledge domain that was reported in Volume 1. The scenario-analysis graphs provide a visual picture of learners' knowledge construction in this domain--of putting together, assembling, and connecting environment, plan, goal, and theme knowledge structures and recombining knowledge to enable interpretation of a situation. Knowledge construction was described in Chapter 2 as the addition of new elements to old structures, the formation of new linkages that create larger chunks in a knowledge structure, and new organizations of knowledge that are more encompassing. The pre- and post-graphs depicted in Figures 3 through 8 provide a visual picture of these aspects of knowledge construction. The graphing technique, with further refinements, may provide helpful information about the nature and results of knowledge construction by learners that will aid understanding of the nature and process of knowledge construction at different developmental levels within a domain. The technique provides an approach by which the knowledge-process interactions outlined in Table 1, and the developmental progression outlined in Table 2, can be made explicit and domain specific. Such information would provide a useful basis for the design of instruction.

Further Research

Further exploration of what appears to be independence of the TRT and the diagnostic is needed. A more explicit understanding of the constructs measured by each, and why they are independent, is needed. There is a possibility that they may not be independent but that a curvilinear relationship may exist between them. This possibility should be explored. Constructs measured by both the TRT and the diagnostic appear to be addressed by the learning environment as indicated by the significant increases in the post-scores compared to the pre-scores. This assumes that the score changes are due to experience with the computer-based video-disc learning environment and not to some other experiences students were also having at the time. Inclusion of a control group in the evaluation of the learning environment is needed to test this assumption.

In a general way, pre- to post-score increases support the theoretical dimensions that underlie the instructional design: (a) fidelity, (b) visualization, (c) wide-ranging and deep-level experiences, and (d) strategic mediation. The data presented in the investigation reported here portray a promising picture regarding the theories underlying the instructional design model and the capacity of the computer-based video-disc learning environment prototype to facilitate the development of mental aspects underlying complex work activities. More specific investigation of the relative contribution of each of these dimensions would be helpful in refining the learning environment and in drawing conclusions about the merits of each dimension. The TRT provides some measure of the effectiveness of the fidelity dimension since this assessment confronts learners with the complexities of situations as they occur in the real world. Evaluation of the visualization dimension would require a comparative investigation that examined the video-disc environment in relation to similar instruction that uses written case studies or other forms of case presentation that do not include visual images. The capacity of the design to provide a range of experiences, deep processing, and mediation that supports learning will be better understood when the data that were collected during learners' interaction with the learning environment and with each other have been analyzed. These data include sequences learners took through the learning environment, time learners spent on various portions of the learning environment, conversations within the small learner groups, and journal entries concerning personal reactions to the learning environment. These learning-process data will allow examination of the theoretical dimensions in terms of learner groupings and the types of mediation learners actually experienced. Future studies should examine the interaction of the dimensions as a potential factor in their consequences for learning.

The notion of criss-crossing the landscape described in Chapters 2 and 3, and the effectiveness of buds in setting the stage for higher level learning and of tendrils in reaching back to connect new with prior learning, will be better investigated when all three levels of the learning environment are in place. Future tests of the learning environment should evaluate all three levels once they have been completed and should involve a sufficient number of participants at each level so that patterns that may be present are revealed.

Because the theoretical importance of learners' developmental levels within the knowledge domain in relation to the levels of the learning environment appeared to have empirical support, learner groupings should be more strategic and based on criteria relevant to learning, rather than on schedules of individuals. However, despite the desirability of strategic learner grouping, it would be unrealistic to assume that the practical factors which governed much of the grouping of learners in this investigation can be completely ignored. Some balance between practical and substantive factors needs to be achieved.

Data produced in this study suggest that 10 hours of instruction is likely insufficient to have much impact on learning, at least on learning of the type measured by the TRT. Some learning did seem to occur for the 10-hour group as measured by the diagnostic. A problem with the 10-hour structure is that only about half of the 10 hours are devoted to instruction because the pre- and post-assessments consume 4 to 5 hours. Future tests of the learning environment should involve learners in a minimum of 20 hours of instruction (including assessments) in order to achieve a broader range of learning than that reflected on the diagnostic only.

Future plans for continued work on the learning environment include (a) analysis of the learning-process data described above, (b) detailed development of the beginning and advanced levels of the instructional prototype, (c) computer programming for these levels, and (d) an evaluation similar in scope to that reported in this publication but involving all three levels of the learning environment and matching of learner-developmental levels with appropriate levels of the learning environment. The experience and data from the evaluation reported here will provide a useful basis for these future activities.

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# APPENDIX

## KNOWLEDGE STRUCTURE DEFINITIONS AND DESCRIPTIONS: SUPPORTING CHILDREN'S SOCIAL DEVELOPMENT

Each type of knowledge structure is defined and described in the sections below. For each type of knowledge structure, its developmental progression is characterized in terms of layers, with Layer 1 characterizing beginning levels of development and Layer 4 characterizing the most advance levels of development. For each layer, examples of expressions that characterize that layer of development are indicated.

*Task Environment*

Definition: Phenomena in the external environment as represented in the individual's perception of the environment. Descriptions of states, features, or occurrences in the environment.

Content Focus: Children in the situation, the physical setting, objects, activities, events, and their physical features, attributes, or observed states; actions of children; perceived changes in environment elements, physical features of adults in the situation.

Layer 1. Directly observed, specific, concrete instances or examples of persons or objects, specific attributes, and features.

Illustrations: Helena (referring to a specific person in the situation)

The blocks in the corner (referring to specific blocks in a specific location)

Mary said, "I'm hungry" (what someone actually said)

Dan tied his own shoe and then tied Tommy's shoe (a specific action taken by someone stated in concrete, rather than categorical, terms)

The dog brought a block to Diane

One child said, "I don't want to . . . "

Layer 2. Categories that can be apprehended by the senses; observed directly; narrow in scope; few concepts subsumed under it. (Main difference between this layer and Layer 1 is that Layer 1 is not a category, but a specific instance; Layer 2 is a category.)

Illustrations: Red trucks and blue trucks

Dolls with eyes that close

Crackers

Clean up

Appendix (continued)

Lunch

Slow, fast

Children, a couple children, some of the children, all the children, the children that weren't helping

Layer 3. Inferred categories and relationships; cannot be directly observed except through a narrower category; cover a limited range of narrower categories.

Illustrations: Task

Accomplishments

Held back

A cooperative effort

Contributed to the cooperation

Worked hard

Age level

Help

Involved

Participating, participated

Layer 4. Idealized, inferred categories; theoretical concepts; do not exist in actuality; are inferred from other inferred concepts; cover a wide range of narrower categories; abstract concepts and principles; very broad scope (subsumes many concepts); hypothetical possibilities or opportunities for activities, occurrences, features, attributes, or states or for actions of children that existed within the environment but that may or may not have been used or enacted.

Illustrations: Norms

Sanctions

Conceptual structure

Temperament

Initiative

Industry

The children's opportunity to think about their participation or role in the task was limited

Appendix (continued)

*Adult Actions*

Definition: Moves made by an agent in the task environment; what the adult in a situation with children did.

Content Focus: Descriptions or reports of adult actions that occurred in terms of their features, qualities, or attributes; timing; how they were carried out; evaluative statements about how well an action was carried out.

Layer 1. Concrete instances of acts or actions the adult engaged in; what the adult said (direct quotes).

Illustrations: She zipped Jake's jacket
He said, "It's okay; I know you don't feel well today."

Layer 2: Actions of the adult or attributes of the actions that specifically occurred in this situation in terms of concrete, sense-apprehended categories that can be directly observed.

Illustrations: The teacher mentioned specific jobs
The adult used the children's names
The adult talked about duties; talked about what was happening
The teacher got down to the children's level
The teacher stayed with them during the clean up
The adult gave specific requests

Layer 3. Actions of the adult or attributes of the actions in terms of inferred categories that cannot be directly observed except through a narrower category; cover a limited range of narrower categories.

Illustrations: He encouraged her, encouraged participation
He offered his assistance
She was directive, supportive, and positive
He forewarned that time would soon be up
He modeled what he was trying to help them understand
She permitted a variety of ways of accomplishing the task
He interacted with the children
He participated with the children
She acknowledged feelings

Praised

He structured the activity

She directed them during the clean up

He ascribed good intentions to the children

Layer 4. Idealized, inferred-action categories or systems; inferred from other inferred-action categories; do not exist in actuality; cover a wide range of narrower categories; highly abstract actions.

Illustrations: He trusted her to follow through

He respected her wishes

The teacher appealed to their sense of independence

*Plans*

Definition: Generalized adult actions or action categories stated as actions that could or should be used to accomplish a plan or a goal; actions that are or were good or not good to do; that should or should not be or have been done.

Content Focus: Focus is on actions that might occur, what actions are recommended; questioning of actions taken or not taken by the adult; planned or hypothetical actions; if this condition, then this action; evaluation of actions in terms of their appropriateness for a situation or goal; their effectiveness in accomplishing a goal; statements that point out opportunities for adult actions; whether or not opportunities for an appropriate action were taken or missed; opportunities and difficulties often encountered in implementing actions; identification of ways to adjust actions (this action would have been better than that action).

Layer 1. Concrete instances of acts or actions the adult might engage in, might have taken; actions that are possible, that could have or should have been engaged in or taken.

Illustrations: She could have let Jake zip his own jacket

He shouldn't have said, "It's too hard."

He could have sung that so-and-so is a very good helper

She should have said, "Put your hats on today because it is cold."

Appendix (continued)

Layer 2. Acts or actions the adult might engage in, might have taken, that are possible, that could or should have been engaged in or taken; attributes of the actions in terms of concrete, sense-apprehended categories that can be directly observed.

Illustrations: He could have told the children in advance that it was clean-up time in five minutes

He could have used a song about picking up

It would have been better to have groups of two or three children working on the clay

It might have been better to point out a chore she could do

Layer 3. Acts or actions the adult might engage in, might have taken, that are possible, that could or should have engaged in or taken; attributes of the actions in terms of inferred categories that cannot be directly observed except through a narrower category; cover a limited range of narrower categories.

Illustrations: I wonder about giving so many instructions to children

She should interact more with the children

He didn't push her to do more than she could handle

Layer 4. Idealized, inferred-action categories or systems the adult might engage in, might use, that are possible, that could or should have engaged in or taken; inferred from other inferred action categories; do not exist in actuality but only through other inferred action categories; cover a wide range of narrower categories; highly abstract actions; attributes of actions in terms of inferred action categories or systems; actions referred to as a complex of actions (pervasive actions that summarize the situation or all-the-more specific actions taken by the adult).

Illustrations: He should have trusted her word rather than check on it himself

Appealing to children's sense of fairness often helps in such situations

*Goals*

Definition: Purposes, intentions, or outcomes sought or desired; event or state desired; motive(s) of an agent in a situation; typically involves change in some aspect of the task environment from a current state to one desired by the adult.

Content Focus: What purpose is accomplished or is desired; the ends sought by actions; often stated in terms of need or want or the extent to which goals were or weren't achieved; consequences of actions on goals, on desired states.

Appendix (continued)

Layer 1. Adult-focused goals; focused on adult's needs, desires, states; on tasks of interest to the adult.

Illustrations: She wanted them to sit down and be orderly

He was trying to make things easier for himself

She was trying to get this activity to work

He wanted to get the job done

Layer 2. Child-focused goals in this situation; goals focused on children's feelings, perceptions, needs, development, interests, learning in this situation; context-bound child-focused goals.

Illustrations: He wanted the girl in blue to feel good about her project

She was concerned that Tommy would have a chance to explore it on his own

She did it so they could learn each others' names

He wanted them to work together

His goal was for them to cooperate

In order for them to interact with each other

Layer 3. Child-focused goals not bound to a particular context or situation; goals focused on specific aspects of children's development and learning in general.

Illustrations: These are good learning experiences for children to learn cooperation

This helps children manage their environment

This helps the children be self-sufficient

This allows children to help each other

Layer 4. Goals stated in terms of broad, general areas of children's development; not bound to a particular context or situation.

Illustrations: In order to enhance children's social development

This contributed to the children's moral development

*Priorities*

Definition: Types of goal relationships; what goal is important to accomplish or what goal is more important to accomplish in relation to other goals that could also be pursued.

Appendix (continued)

Content Focus: What goals have priority over other goals, what outcomes are important; whose needs have priority or importance; long- and short-term goals in terms of their relative importance; individual needs and group needs in terms of their relative importance; statements about the importance of developmental goals.

Layer 1. Statements that reflect priority on adult-focused needs, goals, nonchildren aspects of the task environment.

Illustrations: The job needed to be done; that took precedence

Sanitation was sacrificed for letting the children do it on their own

Getting the children ready in time for their parents was more important in this situation than developing their self-sufficiency

Layer 2. Child-focused statements expressing priority on short-term goals, context-bound, situational goals, group needs; less developmentally significant goals or that detect priority on adult goals over child-focused goals.

Illustrations: Meeting Cindy's need for comfort right then was the most important thing

It was more important to her that the room be orderly than that the children learn responsibility

She was more concerned about her own needs than the children's

Layer 3. Child-focused statements expressing priority on long-term goals over short-term, context-bound, situational goals or more general short-term goals; individual needs over group needs; developmentally significant goals over less developmentally significant goals.

Illustrations: While it caused them some distress at the moment, this contributed to children's learning to work out their own problems

It is important for children to learn to enjoy an activity and to learn to do it on their own

It is more important for one child to be able to express a troublesome thought, even when it takes awhile, and even if the group's play time is shortened that day

This was an ideal opportunity for Christy to feel that she was an important part of the larger group even though it meant that she would miss her special time with her friend

It was more important to support the children's social development in this situation than to worry about the noise

Appendix (continued)

Layer 4. Expression of priority on highly abstract, theoretical-level child-focused goals, purposes, or intentions.

Illustrations: She was really supporting the boy's cognitive development but didn't seem to worry much about his social development in the process

When possible, several areas of children's development should be simultaneously addressed, rather than only one

The chance to build trust among the children took precedence over supporting their independence

*Themes*

Definition: Generalized, overarching ideas, perspectives, views, assumptions and beliefs; reflect patterns over episodes that may vary greatly in context and specific aspects.

Content Focus: Perspectives, assumptions, beliefs, views; attributes characteristics, natures, or qualities; expectations of what people are like, and what, therefore, is likely to occur; opportunities and difficulties often encountered in pursuing goals; implications, consequences, impact of goals on themes; understanding of sources of another's goals; central concepts that summarize the meaning of an entire situation or that group a wide range of situations together.

Layer 1. Perspectives, assumptions, beliefs, views on children, adults or activities or the environment in this situation, on what they are, need, do, think, know, or can be, do, or think; attributes characteristics, natures, or roles to children or adults in this situation; context-bound in that reference as to what the person believes or assumes about children or adults in this situation.

Illustrations: A lot of children didn't know it was clean up at all

The children were self-motivated

Some children did not want to clean up

The children would have been able to do clean up without instructions from the teacher

The children felt capable in their environment

The children felt worthwhile, were relaxed

The children were very capable of handling this activity

The children needed encouraging

The setting was geared to children

Adult was low key, positive

Appendix (continued)

Layer 2. Perspectives, assumptions, beliefs, or views on what one can expect in general about children or adults, their roles, what they are, need, do, think, know, or can be, do, or think; what one can expect in general about situations or activities or environments involving children or adults; what opportunities and difficulties may arise; attributes characteristics or natures of children or adults generally; not context-bound; does not speak about children or adults in a particular situation but about children or adults in general; what the person believes or assumes about children or adults.

Illustrations: I'd expect preschoolers to engage in a lot of social play

Clean up is one of those jobs that children are often not very excited about

Children are valued, are capable

Clean up can be a difficult transition

All children like to hear that they are good helpers

Young people have feelings

Young people should be recognized by name

Children need prompting, to be told

Layer 3. Perspectives about qualities of the relationships between adults and children, or the general climate surrounding interactions or situations that are reflected in a specific situation or that occur generally; general, overarching orientations of adults, not context-bound, but that are reflected across situations; statement of the conditions governing the establishment of a role taken.

Illustrations: A climate of cooperation prevailed

The situation was one in which children were controlled and order prevailed

Guidance from a child's perspective entails sensitivity and responsiveness to children on the part of adults

Layer 4. Large scale, ultimate consequences or implications of goals for children and of qualities of relationships; impact on children's nature, learning, development, their opportunities for development and learning; statements that focus on interests or other factors underlying qualities of relationships.

Illustrations: The children come to rely on external direction rather than being self-directed

The children get to relying on adult intervention

The children come to have a sense of control over what happens to them