To the Graduate Council:

I am submitting herewith a dissertation written by Louis Owen Rabinowitz entitled "Experts Learning: Problem Solving in a Simulated Environment." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Technological and Adult Education.

John M. Peters, Major Professor

We have read this dissertation
and recommend its acceptance.

Accepted for the Council

Associate Vice Chancellor
and Dean of the Graduate School

EXPERTS LEARNING: PROBLEM SOLVING IN A SIMULATED ENVIRONMENT

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

Louis Owen Rabinowitz

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DEDICATION

This dissertation is dedicated to my father,

Mr. Seymour Rabinowitz, and my nephews, present and future.

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ABSTRACT

The purpose of this study was to show that, by critically reflecting on one's own knowledge base and the knowledge base of another in a simulated environment, an expert can learn new ways for solving problems in his domain of expertise. The simulated environment used for this study consisted of both an expert system and hypertext program. The method employed in this research was qualitative and was largely dependent on the phenomenological understanding of two subjects' experiences in solving problems. An interview and analysis method known as the Action-Reason Thematic Technique (ARTT) was central to the research and was used to acquire and analyze interview transcripts of the subjects.

By an examination of three types of rules that were identified from the subjects' acquired knowledge bases, it was determined that the subjects did, in fact, add to, delete from, or otherwise modify their knowledge bases indicating that learning took place.

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CHAPTER I

INTRODUCTION

Dreyfus and Dreyfus (1986, p. 3) contend that expert knowledge consists of "knowing that" and "knowing how." Knowing that relates to the store of rules, norms, and facts in the person's knowledge base, while knowing how is tacit and "the sort of ability we all use all the time as we go about our everyday tasks" (Dreyfus and Dreyfus, 1986, p. 29). Experts can be distinguished from novices on the basis of their superior knowing how in particular narrow domains of knowledge.

This knowing how comes as a result of learning, which to Dreyfus and Dreyfus is a product of experiences. They state

> While most expert performance is ongoing and non-reflective, when time permits and outcomes are crucial, an expert will deliberate before acting. But . . . this deliberation does not require calculative problem solving, but rather involves critically reflecting on one's intuitions. (pp. 33-34)

When an expert deals with problems in a tacit way, he or she does not necessarily consciously draw on the rules embedded in his or her knowledge base. In contrast, the non-expert or novice is more likely to consciously rely upon his or her inventory of rules to solve a problem. Experts and nonexperts alike not only learn to solve problems but they learn in order to refine and build upon their existing knowledge bases. This occurs mainly through the process of "critically reflecting" referred to by Dreyfus and Dreyfus

(1986) above, what Mezirow (1981, p. 11) called "critical reflectivity," and Brookfield (1987, p. 1) called "critical thinking." Critical thinking involves "calling into question the assumptions underlying our customary, habitual ways of thinking and acting and then being ready to think and act differently on the basis of this critical questioning" (Brookfield, 1987, p. 1). Expertise, therefore, is a dynamic quality of mind, subject to change and restructuring in the face of novel problem solving situations. Experts change the set of rules that they use when faced with novel problems. These changes may take the form of additions of new rules and the refinement of old rules. The latter changes, or "replacement rules" may be very subtle, since experts rely so strongly on tacit understandings of problems and their solutions. Novices, who are more likely to learn and rely on textbook information, (Dreyfus and Dreyfus, 1986) are more likely to add original rules to their repertoire than to refine undeveloped tacit understandings and strategies for solving problems. In critically reflecting on their knowledge base both expert and novice might also develop a third type of rule, a "corresponding rule." This type is identical or very similar to an original rule. When verbalized by the problem solver, a corresponding rule would differ from the original rule in insignificant ways, such as in the use of different but synonymous terminology (Dreyfus and Dreyfus,

1986). All three types of rules, original, replacement and corresponding rules, are analogous to "production rules" that form the knowledge base of expert systems. Expert systems are computer programs that have built into them the knowledge of human experts that can be drawn upon to solve problems (Van Horn, 1986). Additionally, expert systems "can become not only tools of convenience but also tools of thought" (Sell, 1985, p. 26). This means that expert systems are not only useful as problem solving aids, but also have potential as learning aids.

If an expert can learn by critically reflecting upon his or her knowledge base, and if an expert system can be used to store and make that knowledge base accessible to the expert, it follows that the expert should be able to learn from critically reflecting on a replication of his or her own knowledge base in an expert system. Moreover, this capability should be enhanced if the expert system is structured around rules that allow the expert to access and move them about the system and discern their interrelationships, their themes, and their relationships to particular decision strategies (Schank and Childers, 1984).

Recent developments offer promise in this regard, especially the development of hypertext programs. An expert system is built in a modular fashion, so that production rules may be added or deleted when the system needs updating. In fact, most are structured to allow updating to

occur as they are used, especially if the user is an expert in the domain of the expert system. However, the addition of a hypertext program to the expert system greatly increases the modularity and flexibility of the system. A hypertext program allows the linking of related themes (extensions of rules) into complex networks of information known as hyperdocuments. Unlike "flat" documents that are produced by word processing programs and which must be read in linear fashion, a hyperdocument is intended to be read on a computer monitor and allows the user to move from one section of text to another section of related material. For users, the many possible combinations of text blocks can lead to development of novel associations of information that in turn lead to unique assortments of rules and problem-solving strategies, as well as modification of the system itself.

In short, when hypertext is added to an expert system the

two together can serve as a simulated environment within which the user can manipulate and reflect upon his or her own rules or other users' rules. This type of interaction simulates critically reflective thinking as defined by Mezirow and Brookfield, and makes the expert system a tool for studying reflective thinking as a feature of adult learning.

Problem

If an expert system in tandem with a hypertext program simulates an expert's knowledge base, and if the expert's interaction with such a system can produce a quantitatively or qualitatively different set of rules for that expert, then the expert whose rules are thusly changed can be said to have learned from the interaction. Moreover, if an expert can learn from interacting with his or her own knowledge base in an expert system and hypertext program, it is possible that he or she can learn from interacting with another expert's expert system and hypertext program. However, no research evidence is known to exist that lends support to the claim that an expert's interaction with an expert system and hypertext program of any origin actually results in changes in the expert's own rules, or that learning results from such an experience.

These questions remain open: (a) Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext program add, delete, or reformulate rules in his or her knowledge base into meaningful units of information, or "chunks" (Cohen and Feigenbaum, 1982, p. 5), as a result of that interaction? (b) Does an expert who critically reflects upon another expert's expert system and hypertext program add, delete, or reformulate rules in his or her own knowledge base as a result of that interaction?

(c) Does an expert who critically reflects upon his or her own knowledge base add, delete, or reformulate rules in ways that are qualitatively different than the expert who reflects upon another expert's knowledge base? (d) If new rules are added or old rules deleted or reformulated in either expert's knowledge base, does the incidence of such changes and the composition of rule changes represent learning?

Assumptions

The following assumptions guided this study:

1. An expert system and hypertext program can simulate an expert's knowledge base.
2. An expert's interaction with an expert system and hypertext program can result in the development of new rules and/or the deletion and reformulation of old rules.
3. The addition to, deletion of, or reformulation of, rules in an expert's knowledge base provides de facto evidence that learning has taken place.
4. The simulated problems which subjects were asked to solve are representative of actual problems within the domain of expertise of the subjects.
5. The subjects' knowledge bases are at least in part constituted by rules.
6. Verbal reports as data are valid representations of rules in an expert's knowledge base.

Purpose of Study

An investigation should be conducted within an interpretive rather than a hypothesis-testing perspective. The adoption of an interpretative perspective does not imply that experimentation is not worthwhile, or that

methodological and explanatory rigor can be abandoned. What it does suggest is that experimentation can be more usefully employed to test and refine a theory or representation which has been arrived at by other means, rather than as a primary discovery procedure for producing a theory in the first place. Experimentation should not take place in the absence of a thorough initial conceptualization of the phenomenon of interest. Therefore, the purpose of this study was to describe the outcome of the interaction of experts with their own and another expert's expert system and hypertext program, as they solved simulated problems in the domains in which they are expert. Such an investigation should lead to a better understanding of the nature of learning that takes place in the form of addition and reformulation of rules in their own knowledge bases.

Significance of Study

The outcome of this study should be a beginning for future research efforts in the area of adult learning in simulated environments. For example, researchers might be able to statistically relate the "mechanics" of learning with expert systems to measures of the level of the user's expertise. Another outcome of the study would be its initiation of a computer-based simulation environment in which reflective thinking and learning are modeled which in turn would allow researchers to study the interaction of the learner with the system. Such a "laboratory" environment is

not currently employed by researchers who study adult learning, but if put into place could lead to significant advances in their ability to study adults learning in highly-controlled research environments.

Limitations

The generalizability of this study is limited by its descriptive nature and by its reliance on only two subjects. However, the use of a greater number of subjects is itself limited by the labor-intensive nature of expert-systems development and protocol analysis techniques described in the methods section. These limitations are considered acceptable,
given the exploratory and descriptive nature of the study.

Definition of Terms

Algorithm. A formal procedure guaranteed to produce correct or optimal solutions. (Office of Solid Waste and Emergency Response, US Environmental Protection Agency, 1988, p. B-1)

Chunk. Meaningful units of information. (Cohen and Feigenbaum, 1982, p. 5)

Expert system. A computer program that uses expert knowledge to attain high levels of problem-solving performance in a narrow problem area. These programs typically represent knowledge symbolically, examine and explain their reasoning processes, and address problem areas that require years of special training and education for

humans to master. (Office of Solid Waste, US Environmental Protection Agency, 1988, p. B-2)

Expert system shell. A shell is essentially an environment that enables the developer to input knowledge in the form of rules, while providing the executable portion of the program that operates on those rules. Unlike a programming language, a shell relieves the developer of the responsibility of computer coding.

Hyperdocuments. Documents developed with a hypertext computer software program.

Hypertext Program. A computer program that allows the user to read text documents in a non-linear fashion. Hypertext documents ("hyperdocuments") are broken down thematically into linked nodes forming a network that is traversed in an order determined by the program user.

Link. In a hyperdocument a link acts as a pathway, determined by the hyperdocument designer, between thematically related buttons and text nodes.

Node. In a hyperdocument, a node is a passage of text that constitutes a discrete theme.

Rule. A syllogism that represents a heuristic used by an expert in solving a problem.

Windows. A graphics-based environment used to integrate two or more computer software programs in a way that appears seamless to the program user. In this paper

"Windows" will be used to refer to the proprietary product of the Microsoft Corporation.

CHAPTER II

RELATED LITERATURE

The following is a review of the literature that addresses expert systems and hypertext, as well as knowledge acquisition.

Expert Systems and Hypertext

Both expert systems and hypertext programs are often cited as being valuable decision aids that can help solve problems. A problem, according to Rubinstein (1986, p. 7)

> . . . exists when the following elements are present in the mind of a human problem solver:
>
> A perceived or initial state
>
> A perceived goal or end state
>
> Perceived obstacles that prevent bridging the gap between the present and goal state.

The early literature of both expert systems and hypertext was concerned with possibilities and conceptual foundations; later literature has dealt with how to construct working programs. In the area of expert systems, limits have been discovered as systems have been built, and early expectations about the potential of expert systems to replicate human problem solving regardless of domain are being changed to reflect a narrow, domain-specific view. For example, Simon and Newell's "General Problem Solver" program was the result of an early attempt to replicate human problem solving ability (Hayes, 1977; Matlin, 1983). After the program was tested, however, it was clear that it

was not capable of problem solving in any generic sense. The failure of such programs as the General Problem Solver influenced the subsequent concept that domain-specificity is characteristic of successful expert systems. The necessity for delimiting the domain of an expert system is inherent in articles by several writers (Brachman, Amarel, Engelman, Engelmore, Feigenbaum, and Wilkins, 1983; Hayes-Roth et al., 1983; Grafton and Permaloff, 1986; Romiszowski, 1987; Office of Solid Waste, US Environmental Protection Agency, 1988).

Minsky (1983) offered the explanation that experts operate within deep but narrow domains. He contended that expert domains are far less complicated than common sense domains. As an example, he offered a comparison of two expert system programs. One was developed as a tool for solving college-level mathematics problems that required about a hundred rules, the other was designed to replicate the processes children use when playing with building blocks and took thousands of rules (or what Minsky refers to as "knowledge fragments," p. 80).

Designing and constructing an expert system is a labor-intensive undertaking. To maximize cost effectiveness and program efficiency, it is incumbent on the builder of an expert system to limit the domain of the program. The most frequently cited technique used for identifying, refining, and otherwise delimiting the domain of an expert system is an iterative process known as "prototyping" (Buchanan et

al., 1983; Prerau, 1987; Office of Solid Waste, 1988; Harmon, Maus, and Morrissey, 1988). Cholawsky (1988, p. 42) provided a particularly cogent description of prototyping:

> As the problem area becomes better understood, more involved prototype efforts are undertaken with more complex implementation, testing, and evaluation. The development team iteratively enhances each prototype until an operational system evolves. In the final development phase, the team is challenged to maintain and enhance end results of the prototyping efforts, transforming the mature prototype into an operational system.

With the advent of effective strategies and methodologies to develop expert systems, interest in their application to real world problems has grown. Along with this increased fascination with the potential of expert systems, hypertext has also emerged to capture the imagination of theorists and entrepreneurs alike.

Not only do the two disciplines have great potential as discrete applications, but in combination their power is greatly enhanced. For instance, the ability to link information in infinite ways is an inherent quality of hypertext that holds promise for its use in prototyping expert systems. However, not much research has been done in the area of combined hypertext programs applications. In fact, a seminal article written in 1945 by Vannevar Bush notwithstanding, the hypertext literature has only recently burgeoned. The Bush article, along with the writings of other hypertext thinkers such as Nelson (1987), discussed the potential for hypertext as a thought processing tool and

medium for organizing and retrieving data.

Other articles have dealt with the actual "nuts and bolts" of hypertext development (Conklin, 1987; Fiderio, 1988; Marchionini and Shneiderman, 1988; Marchionini, 1988; Morariu, 1988; Kearsley, 1988). These articles described the efforts that must go into developing a "hyperdocument" (the computer-based text that results from a development effort) that is structured enough to prevent confusion in traversing the document, but not so structured as to inhibit navigation through the document in a way that maximizes the ability to arrange data in new and unique ways.

Expert systems and hypertext offer a high fidelity person-machine interface that is superior to less interactive computer programs. Therefore, in addition to the design issues described previously, there is also an important human factors issue: the information to be used in the development and prototyping of a system must be acquired from an appropriate human expert. A profile of such an expert, in terms of system development, can be drawn from the literature:

* Experts solve problems faster and more accurately than non-experts (Brachman et al., 1983), and the problems they solve are ones that others cannot solve (Grafton and Permaloff, 1986).

* Expertise is exhibited in narrow domains (Brachman et al., 1983).

* Experts immerse themselves in situations with little conscious effort of what they are doing; they become "fully involved in the situation" and "visualize and

manipulate whole objects and situations" (Denning, 1986, P. 345).

* Experts rely heavily on intuition (Niwa 1986) and heuristics (Hayes-Roth et al., 1983) in solving problems. Such a best guess approach is desirable in certain high risk endeavors where a slight miscalculation based on intuition will not preclude an effective solution, but a gross miscalculation based on a faulty algorithm will (Peters and Hammond 1974).

In addition to the profile above, the literature detailed desirable traits to look for when choosing an expert. Prerau (1987, p. 44) listed desirable traits of the ideal expert. According to his article, the system developer should select an expert who can "communicate personal knowledge, judgment, and experience and the methods used to apply these elements to the particular task."

Additionally, the expert should be introspective, should possess the ability to describe reasoning processes to others who may have little or no knowledge of the expert's domain, should be cooperative and eager to work on the project at hand (at least the expert should be nonantagonistic), and should be willing to commit a great amount of time to the project.

After identifying an expert whose knowledge will be used in the development of an expert system, the knowledge must be acquired and converted into a representation that can be used in an expert system program (what the Office of Solid Waste refers to as "the encoding of human decision-making using symbolic terms or symbols," pp. 1-3).

Logic has provided the symbolic language that is the basis of many knowledge acquisition and representation schemes. Many reasons for using logic are found in the literature. As McCarthy (1977) and Filman (1979) pointed out, the expression of a problem in logic often corresponds to our intuitive understanding of a domain. Green (1969) also claimed that logical representations are easier to reformulate; thus, experimentation is made easier. Hayes (1977) argued for the advantages of logic over other representation systems on the grounds that logic is precise; there are standard methods of determining the meaning of an expression in a logical formalism. Also, logic is modular; logical assertions can be entered in a database independently of each other, and knowledge can grow incrementally as new facts are discovered and added.

Knowledge Acquisition

One problem in developing a system combining an expert system and hypertext program is the need for a means of acquiring, analyzing, and manipulating expert knowledge. This transfer and transformation of expertise has often been cited as an obstacle to expert systems development (Hoffman, 1987). Examples of good practices for knowledge acquisition abound in the literature (Ericsson and Simon, 1980; Prerau, 1987; Hayes-Roth, Waterman, and Lenat, 1983; Buchanan, B. G, Barstow, D., Bechtel, R. Bennett, J., Clancey, W., Kulikowski, C., Mitchell, T. and Waterman, D. A., 1983) but,

as Hoffman (1987) made clear, there has been little research on developing a systematic knowledge acquisition utility. One popular method is called a thinking aloud protocol method. Until recently, research in the area of problem solving focused on well-defined problems in attempts to develop formal models of problem solving processes (Tuma and Reif, 1980; Schon, 1983). Researchers typically engaged subjects in playing games, solving puzzles or computing math problems, and sought to identify patterns of responses that indicated processes of thinking. A classic example of this approach was the work by Newell and Simon (1972) cited above. These researchers would typically present a subject with a problem (e.g., the Tower of Hanoi) and ask that the subject "think out loud" as he or she worked through the problem. The resultant transcript of the subject's verbalizations was analyzed for heuristics (rules-of-thumb) which were effective in the solution of the problem.

Another method can be found in the research of Peters and his colleagues (Peters and Lazzara, 1988; Peters, Johnson, and Lazzara, 1981; and Lazzara, 1985) on a utility that has come to be known as the Action-Reason Thematic Technique (ARTT). This procedure was developed for a research project on adult problem solving and learning in the early 1980s. Funded by the National Institute of Education, the project focused on differences in problem solving approaches undertaken by literate vs. nonliterate

adults. Since then, it has been used as a procedure in studies of several different populations of problem solvers and as a knowledge acquisition method in the development of expert systems (Johnson, Johnson, and Little, 1985; Lazzara, 1985; Sanders, 1983).

The basic structure of the method is an interview-analysis-interview cycle. The interview is an open-ended, probing, yet structured procedure designed to identify the actions taken by the subject while engaged in problem solving and the reasons for actions taken. The identification of actions and reasons is strictly from the subject's point of view, and is accomplished by asking the subject what he or she did to solve the problem and why each action step was taken. In general, the interview involves four steps: (1) the identification of the subject's overall problem or task which forms the basis of the interview about the approach taken by the person in solving the problem; (2) the establishment of the beginning and end of the problem; (3) the identification of actions taken to solve the problem; and (4) the identification of reasons for each action taken.

The first step requires the subject to determine the nature of the problem. The problem is therefore what the subject says it is, not what might be suggested by the researcher or by prompt sheets. Given that most problems are "ill-defined," what counts as the problem space is

almost always determined by the problem solver.

The second step is essential to accurate recall of problem solving activities, and gives both the researcher and the subject a time frame within which to discuss actions and reasons. It also helps to structure the overall episode in terms of the order of actions, whether or not they actually occurred in some linear form.

The third step is based on the assumption that the subject is in the best position to determine what should count as a solution to the problem and actions taken to solve it. Another assumption is that the subject directs his or her behavior according to meanings ascribed to problem or task situations, and the situations and situational meanings will necessarily change as the end of the problem approaches. The challenge of the ARTT is to represent the actions as the subject sees them. One action at a time is identified, and each action is described as it actually happened, not as the subject might characterize his or her general approach to problem solving. For example, an action might be described as "I talked to a specialist about my topic," but not as "I generally talk to people who are specialists in the field."

The fourth step calls on the subject to account for the actions identified in step three. Here the researcher seeks to probe for elements of the subject's reasoning structure that underlies his or her actions. As in the first three

steps, the interviewee is expected to respond in the way he or she intends to be understood. Thus, the researcher does not sit in judgment of the worthiness of the subject's responses, but instead assumes that the way the subject conceptualizes and communicates the actions and a justification for the actions represents the meaning that these elements of the project has for the subject. The interaction between the subject and the object of the problem itself has everything to do with the manner in which the problem is represented.

With reference to the fourth step, it should be said that, when people reason, they argue for a point of view, especially when their reasons are explained to other people. In cases of ill-defined problem situations, the problem solver may be expected to put forth a "practical argument" (as opposed to a formal argument associated with syllogistic reasoning), which is reasoning about what to do. For example, "I wanted a computer. In order to get a computer, I needed money. I got some money." When such an account is given, the person giving it usually describes it in terms of an intentional idiom (Von Wright, 1963). The intentional idiom is the language used when one gives reasons for things that one has done or plans to do. A person's accounts of actions refer to such attributes as his or her beliefs about the world, purposes or intentions,

wants and desires, and the rules of conduct he or she abides by at any given time.

The focus on the intended interpretation is consistent with a view of comprehension that is likewise intentional (Lazzara, 1985). On this view there is a distinction between the literal or direct meaning of a statement and the intended interpretation of that statement uttered in a particular context. Because of this, the researcher must process speech at the level of the idea. This feature of the procedure is discussed in the following section on analysis.

This procedure is called a thematic reduction. (The theoretical foundation for this method is found in Lazzara, 1985.) The interview is transcribed verbatim, and the protocol text is searched for thematic structures which are uncovered in an analysis of ordinary language elements contained in verbal accounts of problem solving actions. The important thematic level of a problem solving protocol is that of the reasoned explanations a person gives for what he or she is doing or did while engaging in project actions. At this level, such themes represent the underlying reasons that drive such actions.

The thematic reduction has three stages. In the first stage, the transcript is segmented into intended ideas or "atoms." "Sentences" as such are not obvious units which exist on the surface of a verbal message. People use speech

not only to communicate, but also to formulate their ideas as they go along. Because they do not generally speak in well-formed "sentences," it is often difficult to decide exactly where one sentence starts and another stops in a written transcript of spoken conversation. The analyst is therefore faced with the problem of identifying the interpretation intended by the interviewee.

The intended interpretation of an utterance is derived from a contextual analysis of the surface structure of the protocol. This means that the general information contained in the transcript (the context) is used to help the analyst decide what a person means by some statement when that statement is not altogether clear or when it has more than one possible interpretation. If a statement does not capture the intended idea, it is paraphrased by the analyst so that it does. An adherence is made to the following rule for paraphrasing: Any paraphrase which necessarily alters the wording of an utterance must be supportable by evidence about the speaker's intentions derived from the overall context. Most of the changes that are made in transcribed statements will be structural, such as: (a) conjunctive phrases are separated into atoms; (b) incomplete ideas are completed on the basis of contextual references; (c) false starts are eliminated; (d) embedded sentences are extracted from their context and paraphrased as separate atoms. At this level of description an atom which is a paraphrase is

just as "valid" as a literal transcription. A paraphrase is arrived at by a coder (or group of coders) who is (are) trained to a suitably high level of reliability with respect to agreement on paraphrasing.

In the second stage the data base is examined for natural and logical connections among those atoms that together form an argument or justification for some action. The process of reduction thus far has eliminated redundancy and tangential information and has reorganized the data so they can be more easily analyzed. Reasons that remain are now examined in terms of their interrelationships with one another, and how they form the structure of the person's argument in favor of taking certain actions in order to accomplish problem solving tasks.

In the final stage the atoms making up an argument are linked together in the form of a diagram that displays the logical structure of the argument. This step is a structural analysis and focuses on the subject's reasoning. The complexity of practical arguments is such that they have various argument threads (reasons, intentions) dispersed throughout the fabric of the conversation (interview) in which they are presented. The analyst's task is that of bringing these threads together without violating the intent of the speaker. The procedure involved is similar to Nolt's (1984) procedure for analyzing practical arguments, which involves identifying the structure of complex arguments that

characterize ordinary discourse, and uncovering both verbally expressed and hidden premises, i.e., unspoken reasons for actions. (In any analysis of arguments, it is necessary to make explicit any part of an argument which has been left unstated.) After the interview is completely analyzed, the process can be repeated using the hidden premises as probes for further and more detailed reasoning about background assumptions. This process results in a model of the problem solver composed of two primary elements: (a) a picture of the problem solving process that the person uses; and (b) a structured record of the person's accounting practices which consists of his or her rule system. The resulting model is, in essence, a depiction of the person's reasoning pattern applied to a specific problem situation. Similarly, an expert system computer program has the ability to replicate the problem solving process and reasoning pattern of human experts.

Because the rudimentary component of an expert system is the rule, and the ARTT procedure is used to reduce knowledge bases to rules, it is an ideal technique for the research described in this paper. According to Peters and Lazzara (1988, p. 5)

> An expert system can serve as a tool for studying reasoning and thinking. For example, the interaction of a learner with a model of his or her own reasoning can become an important learning environment. This environment can in turn become a focus for study. Functioning as a simulation environment, the expert system can serve as a legitimate means of scientific advance. The simulation allows us to test predictions

about the process being modelled while at the same time studying the interaction of the learner with the system.

In the study being described in this dissertation, the "learner" is the expert who is expected to develop additional rules or reformulations of old rules as a result of interacting with an expert system and hypertext program built with the expert's own knowledge base.

CHAPTER III

PROCEDURES OF THE STUDY

Subjects

Two subjects (S1 and S2) with similar experience and qualifications in computer assisted drafting and design (CADD) acted as subjects for this project and were chosen on the basis of a selection interview conducted by the researcher. Each subject graduated from the sam technical community college drafting program at about the same time and each works for the same major engineering firm in Oak Ridge, Tennessee. The CADD department at the Oak Ridge facility is considered a "Center for Excellence" within the larger corporate entity.

A third expert, the manager of the CADD department at the engineering firm at which S1 and S2 are employed, was a consultant to the researcher in the design of simulated domain-specific problems the subjects are to solve. Selection of all three experts was made, in part, because of their considerable experience with computers.

Procedures

The project began with the development of a simulated problem which was solved by two experts. Each expert was considered by his or her peers as having superior knowledge in their subject domain. The experts each have over seven years experience in CADD. The subjects were interviewed about how they solved the problem. The resulting

transcripts were analyzed, and a set of rules were identified from the analysis. The set of rules acquired from one of the subjects was used to build both an expert system and a hypertext program. Both subjects used the resultant programs and were instructed to use a "think-aloud" protocol in describing how they worked through the simulated problem. Then each subject was asked to re-solve the simulated problem. A second interview and analysis cycle was done and a second set of rules identified for each subject. A comparison of the first set of rules was made to each subject's second set of rules for two purposes: (a) to determine any differences in the number of original and replacement rules that may have occurred as a result of the subjects' interaction with the expert system and hypertext program and (b) to determine any qualitative differences in rules that may have occurred as a result of the subjects' interaction with the expert system and hypertext program. The entire procedure was repeated, but in the second cycle the expert system and hypertext programs was developed using rules acquired from S2's interview.

The research procedure consisted of the following ten steps:

1. Selection of a simulated problem by subject matter expert and researcher.
2. Simulated problem posed to subjects by researcher.
3. First interviews conducted with the subjects.
4. Analysis of the interview transcripts.

5. Development of an expert system and hypertext program.

6. Presentation of expert system and hypertext program to subjects.

7. Re-presentation of simulated problem to subjects for second.

8. Second interview of subjects conducted.

9. Analysis of interview transcripts.

10. Procedure repeated, building the second expert system and hypertext program using S2's rules.

Problem Selection

Problems selected for this research met Rubinstein's criteria, discussed in the Review of Literature. They were such that they could conceivably be encountered by the subjects in their work. Details gathered in selection interviews of subjects was used to determine the types of projects they were currently involved in. The researcher and consultant used this information to design simulated problems and to help ensure that the likelihood of the subjects having solved such problems in the past would be slight.

Presentation of Simulated Problem

The subjects were asked to solve, independently, a simulated problem selected and designed by the researcher and expert consultant. The first research problem dealt with developing "seed files" for CADD drawings. Seed files execute instructions that set up parameters for drawings to be rendered. The researcher presented the problem and asked

each subject if he had already solved a similar problem. Neither subject had solved a similar problem. The subjects were instructed to solve the problem, relying on their past education and experience. Each subject was asked to solve the problem in a room equipped with all necessary equipment and told that they could write or type notes as they progressed toward their solution. The researcher then told each of the subjects that, after solving the problem, they would be interviewed about how they solved it.

First Interview

The Action-Reason Thematic Technique interviews, described in detail in the Review of Literature section, were conducted. The interview involved four steps:

1. **Identification of subject's interpretation of the problem.** This delimited the scope of the problem as to how the problem first became apparent and why the respondent determined the situation to be a problem.

2. **Establishment of the beginning and the end of problem.** This step delimited a time frame and helped the subject determine a chronology for problem-solving steps. It also served as an aid in recall.

3. **Identification and probing action steps.** These were the actual steps, in order of their occurrence, taken by the subject to solve the problem.

4. **Identification and probing reasons.** Determined why particular actions were taken. These are not necessarily verbatim statements of the rules subjects used in solving a problem, but rather the reasons for actions, from which rules were deduced.

In order to assure accuracy, interviews were recorded on audio tape. Interview transcripts and tapes were evaluated by the researcher's Major Professor. This ensured

that the interview technique used by the researcher followed proper ARTT procedures.

Initial Interview Analysis

The purpose of the analysis is to depict the process that subjects have gone through to solve the problem. The analysis procedure of the protocol results is a "thematic reduction" and constitutes the method to be used as the analysis of data for this project.

Based on Nolt's (1984) argument analysis, the ARTT technique calls for the diagramming of one argument for each action step extracted from the interview transcript. At a coarser level of analysis, these argument structures form themes. Text segments formatted at this level of the thematic reduction are input into the hypertext program. Using Nolt's method to analyze at a finer level, these arguments can also be easily formatted into rules that can be put into an expert system shell.

The steps of the protocol analysis follow. Examples and much of the text that follows are based on an analysis of procedures used by Nolt (1984) and are from Peters and Lazzara (1988, pp. 240-245).

1. The interview is transcribed from audio recording and notes to paper copy.

2. The transcript is parsed into segments that will be used as hypertext nodes. An example taken from the transcript of an interview with a job analyst follows:

   What I was trying to do was identify the strengths and weaknesses of possible methods. I had already

developed my rating scales. I needed to give a weighting so that I could establish the importance of each criterion, because once you've done all that and have created a chart of the alternatives, criteria and weights, then you have identified the strengths and weaknesses.

3. The elements of the transcript that correspond to an action or reason for an action are bracketed and numbered:

   [(1) What I was trying to do was identify the strengths and weaknesses of possible methods.] [(2) I had already developed my rating scales.] [(3) I needed to give a weighting] so that I could establish the importance of each criterion, [(5) because once you've done all that and ((4) have created a chart of the alternatives, criteria and weights), then you have identified the strengths and weaknesses.]

4. A goal statement is identified which constrains the selection and interpretation of intended ideas. The goal statement used to structure this account is as follows (numbers correspond to bracketed and numbered atoms above):

   1. "I was trying to identify the strengths and weaknesses [of the different methods]."

5. The goal statement is a subgoal of the intention to develop a catalog of methods. Note that there is more than one intended idea in the above example of a segment of protocol. Therefore, the intended ideas that are relevant to the identification of strengths and weaknesses must be distinguished. The second bracketed intended idea yields:

   2. "I developed the rating scales" then the following are obtained:

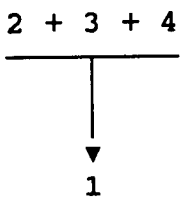
   3. "I needed to give [the methods] a rating"

   4. "[I created] a chart of the alternatives, criteria and weights."

   The following paraphrase is the rule itself as stated by the interviewee:

   5. "[If you do 2 + 3 + 4] then you have identified strengths and weaknesses."

6. The intended idea is diagrammed schematically:



7. The diagrammed intended ideas are structured as if/then rules. The above analysis resolves into the following:

   IF you have developed rating scales AND
   you have weighted the importance of each criterion AND
   you have charted the alternatives, criteria, and weights

   THEN you have identified the strengths and weaknesses

8. Rules for use in the expert system are formatted at this stage of the procedure. The following is an example developed from the if/then rule above:

   RULE Rating scales

   IF rating_scales= developed AND
   criterion= weighted_importance AND
   alternatives_criteria_weights= charted

   THEN strengths_and_weaknesses= identified

Developing the Expert System and Hypertext Program

The expert system program, Paperback Software International's "VP-Expert" (1987), as well as the hypertext program, Owl International's "Guide" (1990), were developed as discrete components. For each problem solved by the subjects, the transcript for the subject from whose knowledge base the expert system and hypertext program were developed was analyzed first in order to produce the programs in a timely manner. Other transcripts were not analyzed until after the subjects used the expert system and

hypertext program developed from S2's second problem transcript.

As shown in the previous section, knowledge in an expert system is coded as rules, if-then arguments structured in a tree-like form that are navigated by the inference engine of an expert system shell. Rules were developed from themes identified in the ARTT analysis. A first version of the expert system was constructed using rules obtained from an analysis of the transcript of the initial interview. A detailed description of expert system development appears in Appendix A.

A hypertext program, Owl International's "Guide" (1990) was used to develop hyperdocuments, which are nonlinear documents that are not intended to be read from beginning to end as traditional documents are. Readers of a hyperdocument navigate through text in an order they determine. Information in text can be combined in a number of ways, leading to new ideas of how to solve problems. Portions of text that can be manipulated by the reader of a hyperdocument are called nodes and are connected to each other by means of links. Themes determined by the ARTT analysis of interview transcripts constitute the nodes that are linked by means of the hypertext program. A detailed description of hypertext development appears in Appendix B.

Interaction with the Expert System and Hypertext Program

Each subject was asked to interact with the expert system and hypertext program for the purpose of determining if he might try a different approach to the original simulated problem. Instructions were given concerning how to use the expert system and hypertext program. Each subject was told to answer queries of the expert system until a conclusion is reached by the expert system. At that point, the hypertext program was invoked and displayed rules from the interview analysis keyed to hypertext themes. Subjects were instructed to read each of the themes in the hypertext program at least once and in any order. Subjects were asked to think aloud about how each theme displayed in the hypertext program influenced the actions taken to solve the initial problem and how the problem might have been solved differently. The purpose of the think aloud technique was two-fold: (a) to ensure that the subjects reflected on hypertext themes and (b) the results were to be used in the researcher's interpretation of the nature of the rule changes that might occur in the second problem solving and analysis cycle. This process was recorded on audio tape for analysis. The researcher was available during each subject's session in order to answer questions and otherwise assist the subject in using the expert system and hypertext program.

Second Presentation of Simulated Problem

Subjects were instructed to solve the simulated problem again. As in solving the problem the first time, subjects were asked to work independently and draw on their education and experience in developing a solution. They were permitted to use necessary equipment in solving the problem and could write or type notes as they progressed toward their solution. The researcher informed the subjects that they would be re-interviewed after solving the simulated problem in a manner similar to the interview done after the first solution was obtained.

Second Interview of Subject Matter Experts

Subjects were re-interviewed about how and why they went about solving the simulated problem. This was done to determine whether new problem-solving rules had been discovered and whether old rules had changed qualitatively. The second interviews were conducted exactly as the first interviews were, using the ARTT interview technique, and recorded on audio tape, and transcribed for analysis.

Analysis of Second Interview Transcripts

An analysis of second interview transcripts was completed to determine whether new rules had been developed and/or old rules had changed. Data acquired from the think aloud protocols assisted the researcher in making judgments concerning classification of new rules.

Repeating the Procedure

The procedure was repeated using the same subjects solving a different problem. The second problem involved designing an office with furnishings. During the second iteration of the procedure, both subjects accessed an expert system and hypertext program created from an analysis of S2's interview. The procedure was repeated a second time in order to strengthen the assumption that changes in the rules are due to critical reflectivity on each subject's knowledge base rather than being due to differences in problem solving capabilities of the subjects due to levels of expertise. The analysis of data proceeded as in the first interview/analysis cycle, with the aim of identifying any differences in the number or quality of rules from one problem state to another.

Analysis of Data

The analysis of interview protocols has been covered in the discussion of procedures in the previous section. What remains is a discussion of how each research question posed in the Problem Statement of this proposal was addressed.

To begin the analysis, new rules were classified as original rules, replacement rules, or corresponding rules.

To answer the first question posed in the Problem Statement, "Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext

program add rules to his or her knowledge base, and reformulate old rules, as a result of that interaction?," a list of rules extracted from S1's second interviews were compared to a list of those extracted from S1's first interview transcript. Corresponding rules on each list were deleted, the difference between original and replacement rules for each set of transcripts determined, and reformulated rules or chunks determined. Replacement rules or chunking determined from the second interview cycle indicated that certain old rules had been reformulated.

The second question, "Does an expert who critically reflects upon another expert's expert system and hypertext program add, or reformulate, rules in his or her own knowledge base as a result of that interaction?" can be answered in a fashion similar to that of the first question. An increase in the number of original rules in S2's second interview cycle, replacement rules determined from the second interview cycle of S2, or qualitative difference in rules or chunks indicate that critical reflectivity on S1's knowledge base has had an effect on S2's knowledge base.

To answer the third question in the Problem Statement, "Does an expert who critically reflects upon his or her <u>own</u> knowledge base add, delete, or reformulate rules in ways that are qualitatively different than the expert who reflects upon <u>another expert's</u> knowledge base?," a comparison of changes in rules from first and second

interview and analysis cycles derived from S1 and S2 when each have accessed their own expert system and hypertext program is made to changes in rules from first to second interview and analysis cycles derived when each have accessed the other's expert system and hypertext program. Changes between first and second interviews and analyses include additions, deletions, or reformulations of rules.

The composition of rules were compared to definitions of learning that results from critically reflected thinking contained in Mezirow (1981) and Brookfield (1987) to answer the fourth question of the Problem Section, "If new rules are added or old rules deleted or reformulated in either expert's knowledge base, does the incidence of such changes and the composition of rule changes represent learning?" This qualitative analysis was, of course, strongly subjective and dependent upon the researcher's own interpretation of what these two writers mean by "learning."

Facilities

Several software programs were required for this research project:

1. "VP-Expert," version 2.0 expert system program shell (Paperback Software International, 1987.)
2. "Guide," version 3.01 hypertext program (Owl International, 1990).
3. "Windows," version 3.1 operating environment software program (Microsoft, Inc., 1992).
4. "WordPerfect," version 5.1 word processing program (WordPerfect Corporation, 1990).

In addition to the software programs listed above, an MS DOS-based personal computer was used in the research.

CHAPTER IV

RESULTS

This chapter contains a description of the data obtained from subjects' transcripts. The data take the form of rules extracted from the transcripts, categorized by rule type (original, corresponding, or replacement rules). The data are addressed in two sections. The first section of the chapter presents the rules in terms of the subject from whose transcript they were obtained and the particular simulated problem on which the subject worked in producing the rules. The second section of the chapter contains a discussion of these rules in terms of the four research questions posed in Chapter One.

Copies of original transcripts from all interviews appear in Appendix C. Copies of analyzed transcripts appear in Appendix D, and the rules obtained from the analyzed transcripts appear in Appendix E. The expert systems and hypertext programs that were developed using subjects' transcripts appear in Appendix F and Appendix G.

Presentation of Data

This section presents rules obtained from subjects' transcripts with respect to rule type, the subject the rule is attributed to, and the problem which elicited the rule.

Coded Data

The rules in the tables that appear in this chapter are organized in terms of a coding scheme that enables the

reader to identify each rule by the subject from whom the rule was obtained, the problem that elicited the rule, whether the rule was obtained from the first or second interview for that problem, and the order in which the rule appeared in the interview transcript. For example RULE 1.1.1.1 indicates that the rule was obtained from S1 after solving problem 1. The rule is from the first interview for that problem, and was the first rule obtained from the interview transcript. Figure 1 below, "Graphic Representation of Rule Numbering Scheme," graphically shows this example.

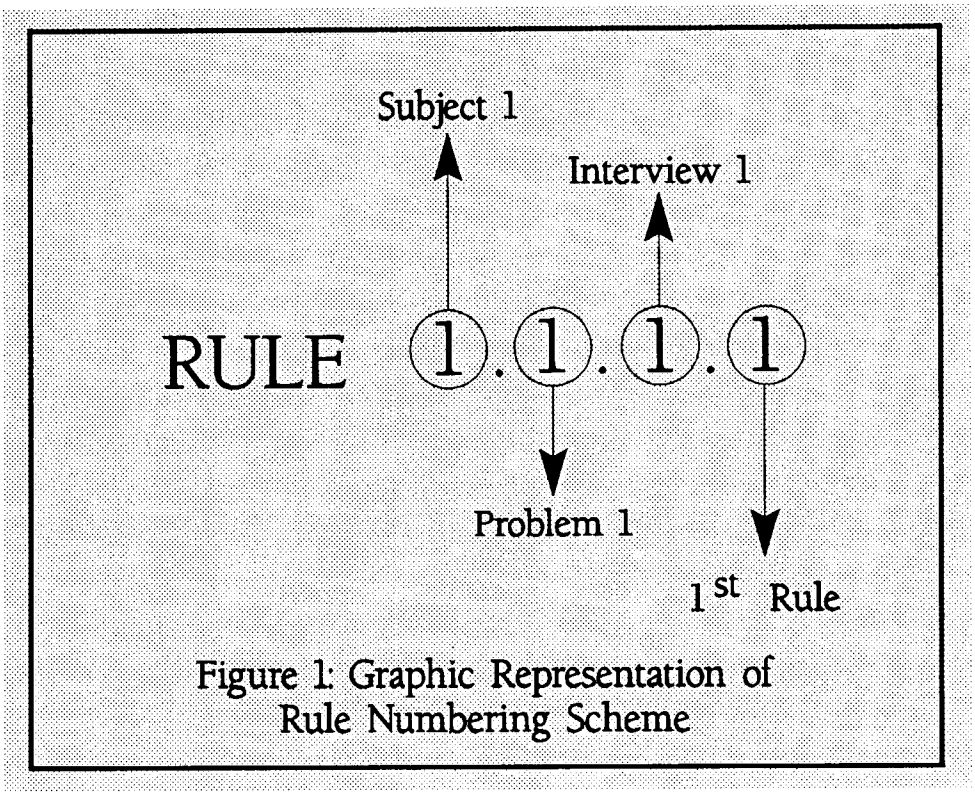


Figure 1: Graphic Representation of Rule Numbering Scheme

Actual Rules and Commentary

The actual corresponding rules, original rules, and replacement rules are presented in this section. Commentary follows each rule or rule set describing the reason each rule was judged to be of a certain type. Rules are given in the following order:

1. Rules acquired from Problem 1, Subject 1 transcript
2. Rules acquired from Problem 1, Subject 2 transcript
3. Rules acquired from Problem 2, Subject 1 transcript
4. Rules acquired from Problem 2, Subject 2 transcript

Each set of rules is followed by a summary table that shows the numbers of each type rule acquired from each transcript.

Rules Acquired from Problem 1, Subject 1 Transcript

Corresponding Rules from Subject 1/Problem 1 Transcripts

RULE 1.1.1.2

IF: mechanical and electrical drawings are done at a scale of one-to-one
THEN: the borders are increased proportionately and there is no need to rescale drawings to fit together

RULE 1.1.2.3

IF: different scale factors are determined
THEN: borders can be set to match each scale factor

Comment: Although Rule 1.1.1.2 appears to be specific to only mechanical and electrical drawings, it is substantially the same as the more generally framed Rule 1.1.2.3. The mention of mechanical and electrical drawings was not a function of the subject's lack of heuristic for scale factors, but rather a function of those specific types of drawings being mentioned in a particular context.

RULE 1.1.1.6

IF: the drawing is rendered for a particular client organization
THEN: the client organization's border is used

RULE 1.1.2.1

IF: the client organization is determined
THEN: the border to be attached can be determined

Comment: Rule 1.1.2.1 is an almost verbatim reiteration of Rule 1.1.1.6 and therefore these rules appear to be substantially the same.

RULE 1.1.1.7

IF: civil/structural and architectural drawings are rendered at a scale of 1/2" to a foot
THEN: the border is scaled at twelve-to-one

RULE 1.1.2.3

IF: different scale factors are determined
THEN: borders can be set to match each scale factor

Comments: Rule 1.1.2.3 and Rule 1.1.1.7 appear to be substantially the same. The specific mention of civil/structural and architectural drawings in Rule 1.1.1.7 is a function of the context of the interview; the subject mentioned the specific types of drawings because those were the types being discussed.

RULE 1.1.1.8

IF: the drawings require a lot of text notes
THEN: the default level should be set to 46

RULE 1.1.2.8

IF: text attributes are to be set
THEN: key in appropriate short commands

Comments: Although Rule 1.1.1.8 includes the specific default level to use, in context of the problem Rule 1.1.1.8 and Rule 1.1.2.8 appear to be substantially the same. Both rules deal with keying in appropriate test attribute information.

RULE 1.1.1.9

IF: mechanical, electrical, and cover sheet drawings are rendered at a scale of one-to-one
THEN: the text sizing should be set at one-eighth of an inch

RULE 1.1.2.9

IF: text size is to be determined
THEN: use scale factor to determine text size

Comment: Both Rule 1.1.2.9 and Rule 1.1.1.9 discuss the relationship of text sizing to scale factors and appear to be substantially the same.

RULE 1.1.1.15

IF: typing 'Control-F' is faster than typing 'file' or using the mouse to save settings
THEN: type 'Control-F' to save the settings

RULE 1.1.2.13

IF: parameters are to be saved
THEN: type Control-F or "file," or pull it off the dialogue box

Comment: The method for saving files described in Rule 1.1.2.13 and Rule 1.1.1.15 appear to be substantially the same.

Replacement Rules from Subject 1/Problem 1 Transcripts

RULE 1.1.1.4

IF: there are only five drawings
THEN: only one seed file is necessary

RULE 1.1.2.2

IF: the size of the job is determined
THEN: The number of seed files to be created for each scale factor can be determined

Comments: Rule 1.1.2.2 appears to be a concept about the number of seed files to be used that is broader in scope than that stated in Rule 1.1.1.4. Rule 1.1.1.4 is specific to a situation in which five drawings are involved; Rule 1.1.2.2 is more general in that it covers any situation regardless of numbers of seed files.

RULE 1.1.1.6

IF: the drawing is rendered for a particular client organization
THEN: the client organization's border is used

RULE 1.1.2.5

IF: the client's procedures are reviewed
THEN: client's requirements can be followed

Comments: Rule 1.1.2.5 appears to be a broader concept about client requirements than that stated in Rule 1.1.1.6. Rule 1.1.1.6 deals only with client organization borders; Rule 1.1.2.5 deals with a review of client procedures that leads to determining all of a client's requirements.

RULE 1.1.1.12

IF: no guidelines are given for dimensioning attributes
THEN: set dimensions according to personal preference

RULE 1.1.2.6

IF: the client's standards are available
THEN: they are used to develop dimension attributes

Comments: Rule 1.1.2.6 states that, when no guidelines are given for dimensioning attributes, personal preference should be used to set dimensions. Because Rule 1.1.2.6 states that client standards should be used to develop dimension attributes, it appears to replace Rule 1.1.2.6.

RULE 1.1.1.12

IF: no guidelines are given for dimensioning attributes
THEN: set dimensions according to personal preference

RULE 1.1.2.7

IF: the client's standards are unavailable
THEN: use company standards to develop dimension attributes

Comments: Rule 1.1.2.7 states that company standards (the subject's organization) should be used when client standards are unavailable. This appears to replace Rule 1.1.1.12 which states that personal preference should govern the dimensioning attributes to use in the absence of guidelines.

Original Rules from Subject 1/Problem 1 Transcripts

RULE 1.1.1.1

IF: there are similarities of various drawing styles
THEN: they are grouped together accordingly

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.3

IF: civil, structural, and architectural drawings have various scale details
THEN: the proportion of the borders might have to be scaled-up to match the proportion of the drawing

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.5

IF: a border is attached to the seed file
THEN: the border is drawn automatically with the drawing

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.10

IF: the grid size used is one-half text size
AND: the text size is one-eighth of an inch
THEN: the grid size is one-sixteenth of an inch

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.11

IF: standard line weights and codes are used
THEN: line code should be set to "one" for text and "zero" for new lines

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.13

IF: it is determined that title headers and details are needed
THEN: the general cell library should be used

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.1.14

IF: the settings of the seed file are saved
THEN: the file maintains the attribute definitions

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.1.2.4

IF: different number of seed files per scale factor is determined
THEN parameters can be set up accordingly

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.1.2.10

IF: the drawing is to be three-dimensional
THEN: set view attributes

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.1.2.11

IF: view attributes are to be set
THEN: turn multiple views feature on

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.1.2.12

IF: views are to be defined
THEN: activate the view number and assign a defined parameter to it

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.1.2.13

IF: parameters are to be saved
THEN: type Control-F or "file," or pull it off the dialogue box

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.1.2.14

IF: the scale of the drawing is to be determined
THEN: determine the size of the object to be drawn

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

Table 1 on the following page, "Rules Acquired from Subject 1, Problem 1 Transcripts," provides a summary of the numbers of each type of rule acquired from Subject 1's first problem transcripts. The table contains three columns, one for each type rule (corresponding, original, and replacement). The first column depicts pairs of corresponding rules from the first and second interview transcripts that are the same or very similar. The second column lists codes for original rules from the first and second interview transcripts. Finally, the third column lists rules from the first interview transcript paired with their replacements from the second interview transcript.

Rules Acquired from Problem 1, Subject 2 Transcript

Corresponding Rules from Subject 2/Problem 1 Transcripts

RULE 2.1.1.1

IF: the project requires five drawings
THEN: use only one seed file

RULE 2.1.2.3

IF: only five drawings are to be rendered
THEN: set up only one seed file

Comment: Rule 2.1.1.1 and Rule 1.2.2.3 appear to be substantially the same.

Table 1: Summary of Rules by Code and Type Acquired from Subject 1, Problem 1 Transcripts

Corresponding Rules		Original Rules		Replacement Rules	
Interview 1	**Interview 2**	**Interview 1**	**Interview 2**	**Interview 1**	**Interview 2**
RULE 1.1.1.2 ⟷	RULE 1.1.2.3	RULE 1.1.1.1	RULE 1.1.2.4	RULE 1.1.1.4 → REPLACED BY	RULE 1.1.2.2
RULE 1.1.1.6 ⟷	RULE 1.1.2.1	RULE 1.1.1.3	RULE 1.1.2.10	RULE 1.1.1.6 → REPLACED BY	RULE 1.1.2.5
RULE 1.1.1.7 ⟷	RULE 1.1.2.3	RULE 1.1.1.5	RULE 1.1.2.11	RULE 1.1.1.12 → REPLACED BY	RULE 1.1.2.6
RULE 1.1.1.8 ⟷	RULE 1.1.2.8	RULE 1.1.1.10	RULE 1.1.2.12	RULE 1.1.1.12 → REPLACED BY	RULE 1.1.2.7
RULE 1.1.1.9 ⟷	RULE 1.1.2.9	RULE 1.1.1.11	RULE 1.1.2.13		
RULE 1.1.1.15 ⟷	RULE 1.1.2.13	RULE 1.1.1.13	RULE 1.1.2.14		
		RULE 1.1.1.14			

RULE 2.1.1.9

IF: text nodes are not to be plotted in the drawing
THEN: turn off the text node feature in the seed file

RULE 2.1.2.10

IF: text node numbers are not to be plotted
THEN: turn off the text node feature

Comment: The wording of Rule 2.1.1.9 and Rule 2.1.2.10 is almost identical and therefore the rules appear to be substantially the same.

Replacement Rules from Subject 2/Problem 1 Transcripts

RULE 2.1.1.4

IF: features are set to the way our office desires
THEN: we set the standards for the company

RULE 2.1.2.5

IF: standards do not exist for some drafting attributes
THEN: reach consensus with others in company to establish those standards

Comments: Rule 2.1.1.4 states that company standards are set based on the desires of those in the office without revealing how those desires are determined, whereas Rule 2.1.2.5 states that a consensus is reached to establish those standards.

RULE 2.1.1.5

IF: locks are one of the first things set up
THEN: then you can be sure that step has been taken care of

RULE 2.1.2.6

IF: the order of setting attributes in the seed file is inconsequential
THEN: set attributes according to preference

Comments: Rule 2.1.1.5 seems to deal with a specific order of setting up attributes. Rule 2.1.2.6 states that there is no compelling reason for setting the attributes in a particular order, but that it is according to personal preference.

RULE 2.1.1.8

IF: a fast computer is used for drawings
THEN: resolution can be set to "high"

RULE 2.1.2.15

IF: the computer is fast
AND: the design file is not large
THEN: use the "slow curve" attribute

Comments: Rule 2.1.1.8 and Rule 2.1.2.15 appear to be similar, in that they both deal with the resolution that can be achieved on a fast computer (the "slow curve" attribute cited in Rule 2.1.2.15 means that a curve can be drawn smoothly as opposed to the curve being composed of several small, straight lines drawn at angles that approximate a curve). The reason Rule 2.1.2.15 is judged to be a replacement for Rule 2.1.1.8 is that it adds that the design file must not be large in order to benefit from using a higher resolution attribute.

RULE 2.1.1.19

IF: office standard for dimension terminators is used
THEN: dimension terminators are filled-in arrows

RULE 2.1.2.2

IF: the client does not have CAD standards
THEN: use company CAD standards

Comments: Rule 2.1.1.19 deals specifically with one type of standard. Rule 2.1.2.2 broadens the concept of the first rule to include using company CAD standards in any case in which client standards do not exist.

RULE 2.1.1.20

IF: dimensions are placed according to office standards
THEN: dimensions are placed above the line

RULE 2.1.2.2

IF: the client does not have CAD standards
THEN: use company CAD standards

Comments: The argument for this pair of rules is the same as for the prior set; Rule 2.1.2.2 replaces Rule 2.1.1.20 because Rule 2.1.2.2 is generic in that it applies to any situation in which client CADD standards do not exist,

whereas Rule 2.1.1.20 is a specific rule related to placement of dimensions.

RULE 2.1.1.21

IF: standard drafting procedures are used to set weight of dimension lines to one
THEN: text will stand out from lines

RULE 2.1.2.4

IF: drafting standards exist
THEN: use drafting standards when setting up the seed file

Comments: Rule 2.1.1.21 relates only to line weight; Rule 2.1.2.4 appears to indicate the use of drafting standards in a broader sense.

Original Rules from Subject 2/Problem 1 Transcripts

RULE 2.1.1.2

IF: the grid lock is turn on
THEN: lines can be drawn to grid points

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.3

IF: the line is to snap to the mid-point
THEN: the snap feature should be set to "two"

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.6

IF: it is rare that a drawing requires increments smaller than an eighth-of-an-inch
THEN: grid spacing is set at an eighth-of-an-inch

Comments: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.7

IF: scale is set up according to the border
THEN: a one-to-one scale is set up in the seed file

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.10

IF: text is to be placed at certain points in the drawing
THEN: turn on the data fields feature in the seed file

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.11

IF: data fields are to be viewed only in certain views
THEN: set up drawing so to be able to switch between views that have data fields set to on or off

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.12

IF: the data field feature is set to off in a certain view
THEN: data fields will not be visible in that view

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.13

IF: underbars are to be visible only in some views
THEN: turn off underbars in view five

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.14

IF: drawing is set up so operator can open desired views
THEN: operator can open any view desired

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.15

IF: the computer used for drawing is fast
THEN: dimensions can be turned on in both views

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.16

IF: bringing in first floor plan as an underlay to the second floor plan is desired
THEN: set up the reference clip feature in the seed file

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.17

IF: the reference clip file is set up
THEN: multiple drawings do not have to be updated

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.1.18

IF: seeing reference clip is not desired
THEN: leave reference clip feature turned off

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.1.2.1

IF: the client has CAD standards
THEN: the client's standards are used

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.7

IF: the drafting job is one of many types
THEN: determine how many seed files are necessary

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.8

IF: if accurate lines are to be drawn automatically
THEN: set up the snap lock feature

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.9

IF: 90° lines are to be drawn from reference lines
THEN: set up the key point feature

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.11

IF: grid is not to display on the screen
THEN: turn off the grid display feature

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.13

IF: curves are to display on the screen quickly
THEN: turn on the "fast curves" feature

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.1.2.14

IF: fonts are to display on the screen quickly
THEN: turn on the "fast fonts" feature

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

Table 2 on the following page, "Rules Acquired from Subject 2, Problem 1 Transcripts," displays the numbers of each type of rule acquired from Subject 2's first problem transcripts.

Rules Acquired from Problem 2, Subject 1 Transcripts

Corresponding Rules from Subject 1/Problem 2 Transcripts

No corresponding rules were obtained from subject 1/problem 2 transcripts.

Table 2: Summary of Rules by Code and Type Acquired from Subject 2, Problem 1 Transcripts

Corresponding Rules		Original Rules		Replacement Rules	
Interview 1	**Interview 2**	**Interview 1**	**Interview 2**	**Interview 1**	**Interview 2**
RULE 2.1.1.1 ⟷	RULE 2.1.2.3	RULE 2.1.1.2	RULE 2.1.2.1	RULE 2.1.1.4 → REPLACED BY	RULE 2.1.2.5
RULE 2.1.1.9 ⟷	RULE 2.1.2.10	RULE 2.1.1.3	RULE 2.1.2.7	RULE 2.1.1.5 → REPLACED BY	RULE 2.1.2.6
		RULE 2.1.1.6			
		RULE 2.1.1.7	RULE 2.1.2.8	RULE 2.1.1.8 → REPLACED BY	RULE 2.1.2.15
		RULE 2.1.1.10			
		RULE 2.1.1.11	RULE 2.1.2.9	RULE 2.1.1.19 → REPLACED BY	RULE 2.1.2.2
		RULE 2.1.1.12	RULE 2.1.2.11	RULE 2.1.1.20 → REPLACED BY	RULE 2.1.2.2
		RULE 2.1.1.13	RULE 2.1.2.13		
		RULE 2.1.1.14		RULE 2.1.1.21 → REPLACED BY	RULE 2.1.2.4
		RULE 2.1.1.15	RULE 2.1.2.14		
		RULE 2.1.1.16			
		RULE 2.1.1.17			
		RULE 2.1.1.18			

Replacement Rules from Subject 1/Problem 2 Transcripts

RULE 1.2.1.6

IF: furniture is placed in the drawing
THEN: furniture can be arranged in the drawing

RULE 1.2.2.5

IF: the size of the office is determined
THEN: furniture can be placed in the design until the office is full

Comments: Rule 1.2.1.6 indicates that furniture is place in the drawing until the space is filled. Rule 1.2.2.5 states that the size of the office is to be determined before the furniture is placed to fill the office.

Original Rules from Subject 1/Problem 2 Transcripts

RULE 1.2.1.1

IF: a lot of light in the office is desired
THEN: place a lot of windows on one wall of the office design

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.2

IF: light is to be dispersed well and high on the walls
THEN: the overhead lighting should be designed to run perpendicular to the narrow dimension of the office

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.3

IF: reduction in the amount of shadow projected by lighting is to be reduced
THEN: design lighting to be oriented diagonally to furniture

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.4

IF: the door is to be opened with the left hand
THEN: the door handle should be placed in the design so that it is convenient to open the door with the left hand

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.5

IF: the office drawing involves one quick design
THEN: the design can be drawn into an already existing drawing

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.7

IF: the drawing is to be rendered with elevations
THEN: the walls are to be modeled up by typing in the appropriate commands

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.1.8

IF: the drawing is to be developed so the edge, corners, and wall coloring are to be seen
THEN: render the drawing as a full hidden line drawing

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 1.2.2.1

IF: the walls have been placed in the drawing
THEN: the floor plan can be created

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.2

IF: the door in the design is to be wide
THEN: use a three-foot wide door in the design

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.3

IF: wall space is to be maximized
THEN: design the door to be in a corner opposite the wall with windows

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.4

IF: the cell library contains graphics of furniture already drawn
THEN: furniture for the office design can be chosen from the cell library

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.6

IF: the file cabinet is to take up minimal space in a vertical direction from the wall
THEN: use a lateral file cabinet in the design

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.7

IF: space for a lot of reference manuals is required
THEN: place a four-by-six-foot bookshelf in the design

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.8

IF: meetings are to be held in the office
THEN: place a guest chair in the office design

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 1.2.2.9

IF: the design arrangement of furniture is based on traffic flow and accessibility
THEN: move furniture in the office design to accommodate flow

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

Table 3 on the following page, "Rules Acquired from Subject 1, Problem 2 Transcripts," displays the numbers of each type of rule acquired from Subject 1's second problem transcripts.

Rules Acquired from Problem 2, Subject 2 Transcripts

Corresponding Rules from Subject 2/Problem 2 Transcripts

RULE 2.2.1.1

IF: inside dimensions are used in design layout
THEN: measurements are easier to work with

RULE 2.2.2.1

IF: an idea of how to design the inside space of the office is desired
THEN: lay out the walls using inside dimensions first

Comment: Rule 2.2.1.1 and Rule 2.2.2.1 appear to be substantially the same.

RULE 2.2.1.5

IF: doors are designed close to a corner
THEN: the design allows for more continuous wall space

RULE 2.2.2.3

IF: the office is to be designed to maximize wall space for placing furniture
THEN: place the door in the design close to one corner

Comment: Rule 2.2.1.5 and Rule 2.2.2.3 appear to be substantially the same.

RULE 2.2.1.7

IF: windows are designed to be three feet wide
THEN: the designer can put four windows across in a twelve foot wall

Table 3: Summary of Rules by Code and Type Acquired from Subject 1, Problem 2 Transcripts

Corresponding Rules		Original Rules		Replacement Rules	
Interview 1	**Interview 2**	**Interview 1**	**Interview 2**	**Interview 1**	**Interview 2**
		RULE 1.2.1.1	RULE 1.2.2.1	RULE 1.2.1.6 → REPLACED BY	RULE 1.2.2.5
		RULE 1.2.1.2	RULE 1.2.2.2		
		RULE 1.2.1.3	RULE 1.2.2.3		
		RULE 1.2.1.4	RULE 1.2.2.4		
		RULE 1.2.1.5	RULE 1.2.2.6		
		RULE 1.2.1.7	RULE 1.2.2.7		
		RULE 1.2.1.8	RULE 1.2.2.8		
			RULE 1.2.2.9		

RULE 2.2.2.5

IF: the back wall is designed to be a twelve-foot wall
THEN: the design can include four three-foot windows in that wall

Comment: Rule 2.2.1.7 and Rule 2.2.2.5 appear to be substantially the same.

Replacement Rules from Subject 2/Problem 2 Transcripts

RULE 2.2.1.6

IF: the designer assumes a wall is an outside wall
THEN: windows can be placed in the design

RULE 2.2.2.6

IF: the software is to generate windows automatically
THEN: use the "window" command

Comments: Rule 2.2.1.6 seems to indicate that the designer must determine placement of windows. Rule 2.2.2.6 indicates that the software can generate windows in the drawing automatically.

RULE 2.2.1.9

IF: it is assumed that the office is being designed for a manager
THEN: there would be a need for storage space and file space, and a lateral file and credenza could provide that space

RULE 2.2.2.11

IF: a piece of furniture that can be used for storage and be attractive is to be placed in the design
THEN: place a credenza in the design

Comments: Rule 2.2.1.9 indicates that there is a relationship between the office being one designed for a manager, the need for storage and file space, and the use of a credenza in the design. Rule 2.2.2.11 does makes use of a credenza in the design contingent only on the need for a piece of furniture that can be used for storage.

RULE 2.2.1.9

IF: it is assumed that the office is being designed for a manager
THEN: there would be a need for storage space and file space, and a lateral file and credenza could provide that space

RULE 2.2.2.12

IF: all the furniture is to be the same brand so it looks the same
AND: a file cabinet is to be placed next to the desk
THEN: place a two-drawer lateral file in the drawing

Comments: Rule 2.2.1.9 deals only with the criteria of the office being designed for a manager and the need for storage space. Rule 2.2.2.12 adds the criteria of the furniture all being the same brand.

RULE 2.2.1.10

IF: a sizable, attractive desk is desired
THEN: a three-foot by six-foot executive desk is a good choice

RULE 2.2.2.10

IF: a desk with extra storage space is to be placed into the design
THEN: use a three-foot by six-foot, two drawer desk in the design

RULE 2.2.1.11

IF: storage space in the desk is desired
THEN: a desk with drawers on both sides should be considered for the design

RULE 2.2.2.10

IF: a desk with extra storage space is to be placed into the design
THEN: use a three-foot by six-foot, two drawer desk in the design

Comments: Note that both Rule 2.2.1.10 and Rule 2.2.1.11 are replaced by Rule 2.2.2.10. It appears that Rule 2.2.2.10 "chunks" information provided in Rule 2.2.1.10 and Rule 2.2.1.11 to form a replacement rule that covers necessary detail about the need for storage and the size of the desk.

RULE 2.2.1.13

IF: the assumption is made that the manager is a forward-thinking manager
THEN: include a computer and computer furniture into the office design

RULE 2.2.2.13

IF: the furniture is to accommodate a good size computer and printer
THEN: place a five-foot by two-foot table in the design

Comments: Rule 2.2.2.13 specifies the size of the computer table needed in the design. Rule 2.2.1.13 only reveals the general concept about the need for computer furniture.

Original Rules from Subject 2/Problem 2 Transcripts

RULE 2.2.1.2

IF: design work is done using a special architectural software program
THEN: the program lays in walls and doors and gives double line walls automatically

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.3

IF: design work is done using a special architectural software program
AND: the program lays in walls and doors and gives double line walls automatically
THEN: the drawing can be converted from 2-D to 3-D

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.4

IF: a standard design software program is chosen
AND: no other design software programs are available
THEN: the standard design software program will be used for design work

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.8

IF: windows are designed to be two-and-a-half to three feet from the floor
THEN: desks can be slid up to walls under windows

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.12

IF: a nice chair is desired
THEN: an executive high-back chair should be consider for the design

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.14

IF: aesthetics are to be included into the design
THEN: consider placing a plant into the design

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.15

IF: the assumption is made that there will be visitors to the office
THEN: include a guest chair in the office design

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.16

IF: the design is to comply to code pertaining to handicap accessibility
THEN: a three-foot traffic area must be included in the office design

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.17

IF: the designer is involved in commercial, industrial, and other types of design work
THEN: handicap accessibility must be included in designs

Comments: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.18

IF: assumptions are made about the type of furniture the manager who will occupy the office might want
THEN: start by laying out the furniture without first considering office size

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.19

IF: code requires a three foot walk area in an office
THEN: you may have to redesign some furniture to accommodate the walk area

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.20

IF: an evaluation of design software programs is undertaken
THEN: the best program for design can be chosen as a standard

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.1.21

IF: fire code requires that certain design features shall exist, including windows in each room
AND: natural light and ability to look outside is preferred
THEN: design will include windows in each room

Comment: No rule derived from the second interview corresponds to or replaces this rule.

RULE 2.2.2.2

IF: the software program is to lay out four walls in the drawing automatically
THEN: use the "place room" command

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.2.2.4

IF: code is to be met
THEN: design the door to be three-feet wide

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.2.2.7

IF: it is determined that the office furniture placed in the drawing fits
THEN: the furniture in the drawing can be arranged to fit the office space

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.2.2.8

IF: it is determined that the office furniture placed in the drawing does not fit
THEN: remove specific pieces of furniture from the design and arrange remaining furniture

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.2.2.9

IF: a software program is to be used to lay out office furniture in the drawing
THEN: use "Project Layout" software program

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

RULE 2.2.2.14

IF: features are to be added to the drawing to obtain a three-dimensional look
THEN: place a telephone into the drawing

Comment: No rule derived from the first interview corresponds to or is replaced by this rule.

Table 4 on the following page, "Rules Acquired from Subject 2, Problem 2 Transcripts," displays the numbers of each type of rule acquired from Subject 2's second problem transcripts.

Discussion of Data

This section contains a discussion of the rules in terms of the four research questions posed in Chapter One. The questions are: (a) Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext program add, delete, or reformulate rules in his or her knowledge base into meaningful units of information, or "chunks" (Cohen and Feigenbaum, 1982, p. 5), as a result of that interaction? (b) Does an expert who critically reflects upon another expert's expert system and hypertext program add, delete, or reformulate rules in his or her own knowledge base as a result of that interaction? (c) Does an expert who critically reflects upon his or her <u>own</u> knowledge base add, delete, or reformulate rules in ways that are qualitatively different than the expert who reflects upon <u>another</u> <u>expert's</u> knowledge base? (d) If new rules are added or old rules deleted or reformulated in either expert's knowledge base, does the incidence of such changes and the composition of rule changes represent learning?

Table 4: Summary of Rules by Code and Type Acquired from Subject 2, Problem 2 Transcripts

Corresponding Rules		Original Rules		Replacement Rules	
Interview 1	**Interview 2**	**Interview 1**	**Interview 2**	**Interview 1**	**Interview 2**
RULE 2.2.1.1 ⟷	RULE 2.2.2.1	RULE 2.2.1.2	RULE 2.2.2.2	RULE 2.2.1.6 → REPLACED BY	RULE 2.2.2.6
RULE 2.2.1.5 ⟷	RULE 2.2.2.3	RULE 2.2.1.3	RULE 2.2.2.4	RULE 2.2.1.9 → REPLACED BY	RULE 2.2.2.11
RULE 2.2.1.7 ⟷	RULE 2.2.2.5	RULE 2.2.1.4	RULE 2.2.2.7	RULE 2.2.1.9 → REPLACED BY	RULE 2.2.2.12
		RULE 2.2.1.8	RULE 2.2.2.8	RULE 2.2.1.10 → REPLACED BY	RULE 2.2.2.10
		RULE 2.2.1.12	RULE 2.2.2.9	RULE 2.2.1.11 → REPLACED BY	RULE 2.2.2.10
		RULE 2.2.1.14	RULE 2.2.2.14	RULE 2.2.1.13 → REPLACED BY	RULE 2.2.2.13
		RULE 2.2.1.15			
		RULE 2.2.1.16			
		RULE 2.2.1.17			
		RULE 2.2.1.18			
		RULE 2.2.1.19			
		RULE 2.2.1.20			
		RULE 2.2.1.21			

Discussion of Data

This section contains a discussion of the rules in terms of the four research questions posed in Chapter One. The questions are: (a) Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext program add, delete, or reformulate rules in his or her knowledge base into meaningful units of information, or "chunks" (Cohen and Feigenbaum, 1982, p. 5), as a result of that interaction? (b) Does an expert who critically reflects upon another expert's expert system and hypertext program add, delete, or reformulate rules in his or her own knowledge base as a result of that interaction? (c) Does an expert who critically reflects upon his or her own knowledge base add, delete, or reformulate rules in ways that are qualitatively different than the expert who reflects upon another expert's knowledge base? (d) If new rules are added or old rules deleted or reformulated in either expert's knowledge base, does the incidence of such changes and the composition of rule changes represent learning?

First Research Question

The first research question was "Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext program add, delete, or reformulate rules in

his or her knowledge base into meaningful units of information, or 'chunks' as a result of that interaction?"

Subject 1's first problem interview transcripts yielded seven sets of corresponding rules. These rules indicate the use of exact or similar strategies during both problem solving sessions. However, the subject's first transcript yielded seven original rules and his second transcript six. Therefore the subject did "add and delete" rules from his knowledge base.

The second interview transcript resulted in four replacement rules. This phenomenon shows that the subject reformulated rules in his or her knowledge base into meaningful units of information.

Similar results were obtained in the case of the results yielded in Subject 2's second problem transcripts. There was a total of three sets of corresponding rules from S2's second problem interview transcripts. This result indicates some reliance by the subject on similar rules from one problem solving session to another. There were, however, thirteen original rules obtained from the subject's first transcript and six from his second. Obviously this subject engaged in considerable "adding and deleting" of rules. The subject's second interview transcript resulted in six replacement rules. This indicates that the subject also engaged in reformulation of rules in his knowledge base.

Second Research Question

The second research question was "Does an expert who critically reflects upon another expert's expert system and hypertext program add, delete, or reformulate rules in his or her own knowledge base as a result of that interaction?"

A total of seven original rules were obtained from S2's first interview analysis, and eight were obtained from the second interview analysis for the first problem. This indicates that rules were deleted and added after critical reflection on S1's knowledge base. One replacement rule was obtained from an analysis of S2's transcripts indicating that a reformulation of a rule occurred.

S1's transcripts yielded no corresponding rules. S1's first interview transcript yielded seven original rules and his second transcript yielded eight. It is apparent that S1 added and deleted a number of rules to his knowledge base after using the expert system and hypertext programs developed from S2's second problem, first interview transcript. One replacement rule was obtained from an analysis of S1's second problem transcripts indicating that a reformulation of a rule occurred.

Third Research Question

The third research question was "Does an expert who critically reflects upon his or her own knowledge base add, delete, or reformulate rules in ways that are qualitatively

different from the expert who reflects upon another expert's knowledge base?"

The researcher could not discern qualitative differences in the way original rules were deleted from either subjects' first interview transcript or added to either of their second interview transcripts. Similarly, there appears to be no discernable difference in the way replacement rules were formulated by the subjects. It appears that for both subjects replacement rules tend to either improve on a previously used rule or otherwise replace a less-than-perfect rule, or to generalize a rule from the first interview transcript in a way that its application is broadened.

While no qualitative differences between the S1 and S2 replacement rules were discerned, what is important is the difference in the numbers of such rules generated by each subject. The S1 first problem transcripts yielded three replacement rules, while the S2 transcripts yielded six. Similar results in the differences in numbers of replacement rules from second problem transcripts were obtained. The contrast in numbers of replacement rules for the subjects may indicate differences in the way the subjects solved the problems introduced in the research.

Fourth Research Question

The final research question is "If new rules are added or old rules deleted or reformulated in either expert's

knowledge base, does the incidence of such changes and the composition of rule changes represent learning?"

As Dreyfus and Dreyfus (1986) have stated, most expert performance is tacit. However, given time and an appropriately crucial situation, an expert will critically reflect on his or her own intuitions. This critical reflection is analagous to Mezirow's concept of critical reflectivity (1981) and Brookfield's critical thinking (1987). Common to all of these concepts is a changing of assumptions and resulting new strategies for solving problems. Or, as stated in Chapter One, this is a dynamic quality of mind, subject to change and restructuring in the face of novel problem solving situations. If the concepts about critical reflection postulated by Dreyfus and Dreyfus, Mezirow, and Brookfield are sound, it would follow that the results of this study indicate that the rules reformulated by the subjects resulted from critically reflecting in the simulated environment described herein and indicate that learning took place.

Implications and conclusions drawn from the findings will be discussed in the following chapter.

CHAPTER V

SUMMARY

The purpose of the study was to describe the outcome of the interaction of an expert with his own and another expert's expert system and hypertext program as he solved domain-specific simulated problems. The intent of the investigation was to lead to a better understanding of the nature of learning that takes place in the form of addition and reformulation of rules in an expert's own knowledge base.

Two experts with similar experience and qualifications in computer assisted drafting and design (CADD) who worked for the same engineering firm in Oak Ridge, Tennessee solved two problems created by a third CADD expert. Each subject had the same degree in drafting from a local technical community college, and each had over seven years experience in the field. The CADD expert who provided assistance in developing problems to be solved by the subjects was the manager of the CADD department at the facility the subjects worked at.

The subjects were interviewed about how they solved the problems and resulting transcripts of audio-taped interviews were analyzed for rules the subjects employed in solving the problems. These rules were used to build expert systems and hypertext programs. Each subject used the resultant programs and were instructed to use a "think-aloud" protocol

in describing how they worked through the simulated problems. Each subject was asked to re-solve the simulated problem within a week to 10 days of the first problem solving events. Second interview and analyses cycles were completed and a second set of rules identified for each subject. A comparison of the first set of rules was made to each subject's second set of rules. This comparison enabled the researcher to address four questions posed about changes in subjects' knowledge bases that may have taken place as a result of critical reflection. The findings relating to each question are summarized in the following section.

Findings

Question One

Does an expert who engages in critically reflective thinking about elements of his or her own knowledge base contained in an expert system and hypertext program add, delete, or reformulate rules in his or her knowledge base into meaningful units of information, or "chunks," as a result of that interaction?

The experts did add, delete, and reformulate rules in their knowledge base after critically reflecting on their own knowledge base. After reflecting on his own knowledge base, Subject 1 added six rules, deleted seven rules, and reformulated four rules. Similarly, after reflecting on his own knowledge base, Subject 2 added six rules, deleted 13 rules, and reformulated six rules.

Question Two

Does an expert who critically reflects upon another expert's expert system and hypertext program add, delete, or reformulate rules in his or her own knowledge base as a result of that interaction?

Each expert did add, delete, and reformulate rules in their own knowledge base after critically reflecting on the knowledge base of the other expert. Subject 1 added eight rules, deleted seven rules, and reformulated one rule after critically reflecting on Subject 2's knowledge base. Subject 2 added seven rules, deleted 13 rules, and reformulated six rules after critically reflecting on Subject 1's knowledge base.

Question Three

Does an expert who critically reflects upon his or her own knowledge base add, delete, or reformulate rules in ways that are qualitatively different than the expert who reflects upon another expert's knowledge base?

This question could not be answered conclusively based on the research, at least as related to whether there were qualitative differences in individual rules of a certain type. In other words, it is impossible to ascertain from this research whether an original, corresponding, or replacement rule obtained from Subject 1 is any different, qualitatively, from an original, corresponding, or replacement rule of Subject 2. What can be determined is

that each subject produced a different number of replacement rules that may indicate some qualitative differences in the way problem solving was approached. Subject 1 produced five replacement rules, while Subject 2 produced 12 pairs of replacement rules.

Question Four

If new rules are added or old rules deleted or reformulated in either expert's knowledge base, does the incidence of such changes and the composition of rule changes represent learning? According to an assumption of this study, that the addition to, or deletion of, rules in an expert's knowledge base provides de facto evidence that learning has taken place, the answer to the fourth research question is yes. Several rules were added or deleted in both subjects' knowledge bases. Subject 1's second interview transcripts yielded a total of 14 new rules, and 14 rules were deleted from his first interview transcripts. Similarly, Subject 2's second interview transcripts yielded thirteen new rules while 26 rules were deleted from his first interview transcripts.

Conclusions

According to Dreyfus and Dreyfus (1986), the refinement and building of one's knowledge base is a form of learning that comes about as a result of critical reflection. This research demonstrated that "refinement and building" took place indicated by changes in the way subjects added,

deleted, or reformulated rules before and after critically reflecting on both their own knowledge bases and those of the other subject. The expert systems and hypertext programs that were developed from subjects' interview transcripts were apparently effective artificial environments through which the subjects could critically reflect.

Rules obtained from subjects might have degraded somewhat when placed into the expert system shell. This is because the expert system shell program used for the research requires that rules be coded within certain guidelines. For instance, production rules may not contain certain reserved characters and must follow a format recognizable by the shell. In a sense, some rules obtained from subjects' transcripts were modified when put into the expert system, prior to the subjects even having accessed the programs. Again, this is due to the nature of the way rules had to be coded for use by the expert system shell.

In addition to the opportunities for critical reflection that were afforded by the simulated environment of the expert system and hypertext program, the iterative nature of the ARTT interview technique, itself, offered opportunities for such reflection. As each interview progressed, subjects had opportunities to refine information that was being shared about how they solved specific problems. This "thinking aloud" may have given rise to

responses that were more along the lines of "the way it should be" as opposed to a faithful reporting of how the subject actually solved a problem.

Implications for Future Research

An important element of the research is that an artificial environment comprised of an expert system and hypertext program was used to create an opportunity for critical reflection. The resultant changes in the subjects' knowledge bases suggests promise for future research in this area and opportunities for helping experts learn new problem solving strategies. This might best be done in controlled laboratory conditions using a quantitative, experimental approach.

There would be some value in redesigning the approach used for this research. The Action Reason Thematic Technique (Peters and Lazzara, 1988; Peters, Johnson, and Lazzara, 1981; and Lazzara, 1985) used in the acquisition of knowledge from the subjects is phenomenological in nature; information obtained from subjects is highly dependent on those subjects' very personal experiences of solving given problems. This experience, when described in an interview session, depends on the interaction of subject and interviewer. This situation is also phenomenologically dependent. While the rapport and understanding that develops between subject and interviewer can be helpful to the interviewer in analyzing transcripts in context, it can

also lead to tacit understandings between the subject and interviewer that impedes the acquisition of knowledge in the second interview for a given problem. Much understanding of the problem domain on the part of both subject and interviewer is assumed and details that would be shared between two "strangers" is omitted. Therefore, the obvious implication for designing similar research would be to have two skilled interviewers conduct interviews, one for the first problem solving session, the other for the second. This would minimize the possibility of faulty assumptions by either the interviewer or respondent concerning the interviewer's knowledge of the subject being discussed.

Another modification to the research design that might be made would be to present the findings to a panel of subject matter experts and have them assist in categorizing rules as original, corresponding, or replacement rules. A Delphi probe could be used to help experts classify the rules.

There is a possibility that individual differences in critical thinking ability might have accounted for observed variations in rules produced by the experts in this study. Future research might explore the possibility that different levels of critical thinking are associated with learning in simulated environments.

While the research reported in this paper found that two problem solving events using the same problem may lead

to learning, it is important to determine whether rules used in solving one problem might be useful in solving a different problem in an expert's problem domain. Future research could be used to compare the learning that occurs when subjects solve two different but related problems.

Implications for practice

The research indicates the ARTT interviewing technique can be an effective means of interviewing for information. A real-world application of the technique includes interviewing to gain information from an expert during a job and task analysis. The iterative nature of an ARTT interview would enable the subject matter expert to refine details from one interview session to another.

Another practical application would be to use rules obtained from interviews in both computerized and hard-copy text formats for training purposes. The findings of this research indicate that the novice as well as the expert can learn from the knowledge base of a third party.

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APPENDIXES

APPENDIX A: EXPERT SYSTEM DESIGN CONSIDERATIONS

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The rudimentary component of an expert system is the rule. A rule extracted from an interview transcript must be formatted in such a way that it can be used by the expert system shell program. "VP-Expert" (Paperback Software International, 1987), the expert system shell used in this research project, requires that valid rules be formatted to include the following:

1. **A rule name.** Each rule must have a unique name of between 1 and 20 characters. Not only is this a requirement of "VP Expert" but, as Prerau (1987) points out, this is good practice. There is a distinct advantage in naming rules over other methods of identification such as assigning them numbers. Adding new rules would necessitate renumbering. Names, however, do not change and have the added benefit of being descriptive of the rule's content.

2. **A rule premise.** Each rule must have a premise in which up to ten conditions are stated. Conditions compare contents of a variable to a value. Relational operators such as = (equals), < (less than), and <> (is not equal to) are used to make comparisons.

3. **A rule conclusion.** The rule conclusion must consist of at least one equation that has both a variable and a value. If the premise of the rule is true, the equation assigns the value of the variable and the rule "passes."

Note that when the system queries the user, it does so using a natural language interface. Rule coding and rule constitution, as well as other routines necessary for the system to function, are largely transparent to the user.

The scope of the system is restricted to a very narrow portion of the SME's domain, and its performance would

suffer dramatically if attempts were made to apply it outside of that domain. While limited to a narrow focus, the expert system must be continually validated while under construction. In relation to expert system development, validation means running the system each time a rule or rules are added in order to make sure responses to a particular set of queries do not lead to a dead end, a situation in which a solution to the problem is not reached.

The user of the expert system is guided by queries posed by the program on the monitor screen. The user responds to the queries by using the cursor keys to move a lightbar over his/her desired response and pressing the Enter key. The lightbar inverts text on the screen such that it is a different color than surrounding text and is boxed. After responding to a sufficient number of queries, the program will display the solution to the problem under investigation. Note that the expert system shell program being used for this research project, "VP Expert," allows the program developer the option of entering variables that may change the ultimate solution. Because it is desirable to replicate the actual problem-solving process engaged by the subject, the option of entering variables will not be exercised.

APPENDIX B: HYPERTEXT AND HYPERDOCUMENT DESIGN CONSIDERATIONS

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Hyperdocuments have embedded buttons, links, and nodes. Buttons are words that are displayed in a special way in the hyperdocument, for instance, in italics. When the user of the system places the cursor over a button and presses the key on the input device, a new display will appear on the monitor screen. This display will contain information related to the button pressed. The information in the display constitutes a node. Buttons and nodes are networked invisibly by links created by the designer of the hyperdocument.

Because nodes are synonymous with themes determined during interview analysis, the themes are well-suited for hypertext development. Each theme determined in the ARTT analysis will be given a unique name and saved as a separate computer file. The hypertext program will retrieve a particular theme when the user chooses the theme's corresponding button.

Note that the researcher may have to query the subject in order to fully understand the meaning of jargon words that may be synonymous to other jargon words or to more common words used in the interview. The analyst must also be aware of terms misused by the subject. In such cases the analyst will use context to determine what the subject meant and may substitute a more accurate term.

The researcher will use a hypertext development program,

"Guide" (Owl International, 1988), to generate the hyperdocument. "Guide" allows for the development of several types of buttons:

1. An expansion button replaces the button with text, graphics, or more buttons.
2. A note button displays a definition in a pop-up window.
3. Command buttons are used to control and access information outside of "Guide," such as another software program.
4. A reference button displays another, discrete, node.

The buttons in the hyperdocument created for this project will consist of reference buttons. Reference buttons will best serve the purpose of displaying discrete themes acquired in the ARTT analysis.

APPENDIX C: SUBJECT INTERVIEW TRANSCRIPTS

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This appendix includes verbatim transcripts of research interviews.

Subject 1
Problem 1
Interview 1
TRANSCRIPT

Problem: Set up the seed file(s) for a project with a maximum of five drawings (one each of the following: mechanical, electrical, civil/structural, architectural, cover sheet).

I: Michael, when did you first start to solve the problem?

S: On the 7th.

I: April 7. Okay. When did you finish solving the problem?

S: On the 7th.

I: So you solved the problem all in one day.

S: Yeah . . . in give or take an hour.

I: What's the first thing that you did in solving the problem?

S: I wrote down ideas as I went along. There are similarities of various drawing styles . . . I grouped them together accordingly.

I: Why did you do that?

S: Several reasons . . . the mechanical and electrical are so similar that they can be drawn at, what I'm going to call, a scale of one-to-one . . . where the border is going to have to be increased proportionately with the scale of the drawing. Everything can be done just by slapping in little parts of the drawing, just put 'em all in -- not have to worry about scaling 'em up, and fit together. Civil, structural, and architectural -- a lot of them have various scale details . . . so therefore the borders might have to be scaled up to match the proportion of the drawing. So I kind of narrowed it down to needing only, absolutely needing, only two seed files.

I: What is a seed file?

S: When you go into Intergraph to create a new drawing, that is the file that the program reads to create a new drawing . . . the way I look at it is like planting a seed to a plant. Once you plant a seed, from that point on, everything grows from that seed . . . all your drawings . . . so all your new drawings originated from the seed file . . . in essence your copying the seed file with parameters already set up in that file, where you don't have to go set 'em every time you make a new drawing.

I: Okay. So every time you start a new drawing you start a seed file?

S: Um . . . hmm.

I: And that's the basis for all of your drawings for any particular project?

S: Right.

I: So the first thing you did in this particular project was to determine the similarity of drawings and group them. You say the electrical and mechanical you group together because, pretty much, they use the same scale?

S: Right.

I: And then civil/structural and architectural are similar . . . they also have the same type of scale and you can use the same seed file for both of those types.

S: Correct. And given that there were only five drawings at the end of the project, only one seed file was absolutely necessary.

I: So you set up one seed file for all five types of drawings?

S: Um, hmm. I attached a border to the seed file, therefore when you create your drawing, your drawing border comes in automatically, you don't have to go search for it and attach it, it comes in right with the drawing.

I: Why do you attach a border?

S: It pretty much saves time. When you create a drawing using that correct seed file, the border's already there.

I: What is the purpose of the border?

S: You have to have a border on 90% of your drawings. Like TVA, for example, they've got their own border they've asked

us to use. So when we do a TVA drawing, we use a TVA seed file with a TVA border already attached to it.

I: What does the border have on it.

S: Titling, project names, numbers, dates, engineers' names.

I: So the first thing you did was determine similarities of drawings and you combined mechanical and electrical because they're the same scale, and you combined civil/structural and architectural for pretty much the same reason. But you told me you only need one seed file for all of those . . .

S: The reason being, there's not enough drawings to concern myself with multiple seed files.

I: So you used one seed file for all of them. Why did you group them since you're only using one seed file for all of them?

S: On a larger project I would most definitely group them together . . . and the civil/structural-architectural . . . when you have a drawing of a scale of 1/2" to a foot, you have to scale the border up twelve times within that seed file, so therefore, that's what I mean that mechanical-electrical is one-to-one, meaning the border scale is one-to-one and you don't have to scale it. If there's a bunch of details like civil/structural-architectural, you'll need to scale up the border to twelve times.

I: Are your drawings bigger for civil/structural than they are for mechanical electrical?

S: Right.

I: But on this particular problem, you only did one seed file for all of them because there were only a small number of drawings?

S: Right.

I: So you didn't actually have to group them for this particular problem.

S: Once I realized the number of drawings, it turned out to be a wasted step.

I: Did you do that step in this particular project before you determined it was wasteful?

S: Um, hmm.

I: So the first thing you did was determine the similarities and group them. Then you attached a border. Then you scrapped the idea of grouping because there weren't that many drawings. What was the next thing that you did after you scrapped the idea of grouping?

S: I went into the seed file and set up all the parameters that I personally like to use and recommend.

I: What were some of those parameters?

S: Text sizing, grid spacing, default level, line weights and codes, and dimensioning attributes.

I: So you draw on a grid.

S: Um, hmm.

I: What did you say after grid spacing.

S: Default level.

I: What is "default level?"

S: When you go into a drawing, you're generally on level one, but since a lot of the text you place in a drawing is on level 46, for general note-taking and so forth, I made that default.

I: And after setting default level, what did you do next?

S: Set line weights and codes and dimensioning attributes.

I: What are "dimensioning attributes?"

S: That's style of dimensions to be placed -- what types of arrowheads to be used.

I: Anything else after dimensioning attributes?

S: Then I attached the border.

I: A little bit earlier, I had that you determine similarities of drawings and group them, then you attach the border. But you didn't actually attach the border until after you set the parameters. So this step actually came down here someplace?

S: Right.

I: Attach the border . . . let me go back to text sizing. How did you determine what size text to use?

S: Standard is an eighth of an inch. Go back to the separations and similarities . . . you've got mechanical, electrical and cover sheet -- when you have a drawing at a one-to-one scale, your text sizing is going to be an eighth of an inch. So you've got three out of the five drawings are going to be an eighth of an inch.

I: In this case, you knew that three of the five drawings were going to be one-to-one scale, then you determined that one-eighth of an inch was going to be the appropriate scale.

S: Right.

I: Then grid spacing -- how did you determine that?

S: That's usually half of the text size.

I: So if the text size is one-eighth of an inch, the grid size is one-sixteenth of an inch?

S: Uh, huh.

I: So, is that what you used in this case.

S: Yes -- that's pretty common, typical.

I: The default level you mentioned is usually level one, but because there is a lot of text in this one, you set a default of 46.

S: Right.

I: Is that pretty standard?

S: Uh huh.

I: How did you determine line weights and codes?

S: One is the standard for text, and line code zero is standard for text and any new lines you have to draw . . . straight line.

I: So for this particular problem you decided to use standard line weights and codes?

S: Um hmm.

I: And why did you decide they were appropriate.

S: In 99% of the cases its what would be standard.

I: Is that the rule-of-thumb that you used?

S: Yeah.

I: The dimensioning attributes that would include such things as arrowheads -- how did you determine those attributes.

S: I set 'em to what I usually like.

I: Is it a personal preference kind of thing?

S: Pretty much -- drafting standards still have a lot to do with it, but I set 'em to what I like since I didn't have any guidelines.

I: Talk to me about the arrowheads -- is there a certain name for the arrowheads? Or, how would you describe the arrowheads?

S: A filled-in arrowhead.

I: What about the sizes of the arrowheads or the shape -- anything special about that?

S: It's . . . the length of it is equal to the height . . . text height.

I: So the length, in this case, was one eighth inch?

S: Um hmm.

I: And when you do a drawing, do you typically use that as a rule-of-thumb?

S: Yeah, you don't have any control over the length of the terminator arrowhead. It reads the text height and sets it for you according to the text height, so you don't have much control.

I: Okay . . . what other attributes did you have some control over?

S: Default cell library that is attached to the drawing.

I: The "default cell library?" What is the default cell library?

S: Cell libraries consist of parts of the drawing, like a section bubble or something pretty typical that you build in one area. Then you can attach that file to your drawing and place all the parts in the file. So I determined the general cell library would contain all the common . . . the

most common, needed details like the heading bubbles, section cut bubbles, and that kind of thing.

I: For this particular problem, why did you determine they would be the standard ones that you'd use.

S: Well, because you'll place the titles and that on the drawing, and that's where this library comes in handy -- it's got all the title headers and details.

I: So for this particular drawing you decided that this was the appropriate thing to do.

S: Um hmm.

I: Just to summarize -- you determined the similarities of the drawings and you grouped them electrical-mechanical and cover sheet and decided that one-to-one scale was appropriate. You grouped civil/structural and architectural and decided that they seemed to fit together. Then you scrapped the idea of grouping due to the small number of drawings for this particular problem. Then you set the parameters of the seed file, including text sizing -- and you determined that text sizing should be one eighth of an inch because that's pretty standard for one-to-one scale drawings.

S: Um hmm.

I: Then you determined the grid spacing, and that's one-half the text size. So for this particular drawing -- or set of drawings -- your grid spacing is one-sixteenth inch. Then you set the default level and, while most of the time you set it at "one," this time you set it at 46 because of the amount of text in this set of drawings.

S: Um hmm.

I: Then you set the line weights and codes. You set your line weight to "one" and your code to zero because that's standard operating procedure and you decided that would be appropriate for this set of drawings.

S: Right.

I: You set your dimensioning attributes. There are standard drafting practices to determine your styles and dimensioning attributes, but the bottom line is that in that range of acceptable practices you determined the ones you liked.

S: Um hmm.

I: Then you attached your border. You mentioned TVA. Is this set of drawings for TVA or someone else?

S: No, I think this was for the "Corps."

I: The Army Corps of Engineers?

S: Um hmm.

I: So did you use their standard border?

S: Yes.

I: So the way you determined which border to use was to use their standard border?

S: Right.

I: What did you do after you set your parameters of your seed file?

S: I saved the settings of the seed file.

I: Why did you do that?

S: Otherwise, it won't keep some of these attribute definitions.

I: After you set the attribute settings, you save the seed file.

S: From that point on, you don't have to save them again.

I: What did you do to save the settings? What is the actual procedure?

S: Control-Z . . . no, control-F.

I: Why did you use control-F? Is that the standard?

S: Yes, and it's faster than typing in "file."

I: You could save it by typing in file?

S: Yes, or you can use the icon on the screen, but you have to search for it.

I: So control-F for you is easier than searching for the icon and clicking with a mouse?

S: Right.

I: After you save the settings, what was the last thing you did?

S: That was pretty much it.

I: So that's the whole process of setting the seed file.

S: Um hmm.

I: You started the process on April 7 and finished that same day. It took you about an hour to solve the problem. The first thing you did was to determine the similarities of drawings and group them electrical-mechanical and cover sheet, because they're all one-to-one scale. Then you grouped civil/structural and architectural -- and they're the same scale. Then you scrapped the idea of grouping because of the small number of drawings involved for this particular problem. Then you set the parameters of your seed file. Now, did you decide to use a one-to-one scale for all the drawings?

S: Right.

I: Regardless of the fact that civil/structural and architectural are smaller scale?

S: Larger scale. There is a need to scale up the border, so everything set in proportion, and when you scale things up in proportion you can easily determine what size to set your . . . like your text height, and everything again. Given the fact that there are only five drawings and three of the five will be eighth of an inch text sizing, I figured that's the easiest way to go.

I: So you went one-to-one because the majority of the drawings were one-to-one anyhow?

S: Um hmm.

I: But if the majority of the drawings were some other scale, that's what you would have used to . . . go to that scale instead of one-to-one.

S: Right.

I: So you scrapped the idea of grouping due to the small number and used a one-to-one scale because three of the five drawings used that scale anyway. Then you set the parameters of the seed file. You set the text sizing, which was one-eighth of an inch when it's one-to-one scale; you set the grid sizing, and your rule-of-thumb for that is one-half text sizing to determine grid sizing; you set the

default level, and you set it to 46 because of the amount of text in these drawings . . . typically you'd set it to one.

S: Um hmm.

I: You determined the line weights and codes and thought the typical line weights and codes would be appropriate for these drawings.

S: Right.

I: You set the dimensioning attributes, and within a range of acceptable drafting practices you used your own good taste or desires in picking your dimensioning attributes. Then you attached a border. And the border you attached was the Army Corps of Engineers' border, because that's who the client is.

S: Um hmm.

I: Then the final step was to save all settings, and you saved all settings by typing control . . . pressing the control key and the "F" key simultaneously. And the reason you did that was, even though there are two other ways of saving the settings, you liked it best because it is faster than typing the word "file" or clicking on the file icon.

S: Right.

I: Okay. Thanks a lot.

Subject 1
Problem 1
Interview 2
TRANSCRIPT

Problem: Set up the seed file(s) for a project with a maximum of five drawings: one mechanical, one electrical, one civil/structural, one architectural, and one cover sheet.

I: This is the second interview on the problem, and you've gone through both the expert system program and the hypertext program. What is the first thing you'd do in setting up the seed file?

S: I'd have to determine the organization, the job organization you're working for, to attach the border, attaching the border for that seed file.

I: So you'd determine the client organization that you're working for?

S: The client. Whether their border needs to be attached to the seed file.

I: What would you do after you've determined whether you have to attach a client border to the seed file?

S: I would take in mind how big the job is . . . to get an idea of how many seed files I'd actually have to create for each various scale factor involved in the project.

I: Scale factor? What do you mean by that?

S: Might have a floor plan that requires a quarter-inch-to-a-foot drawing. And you might have some detail layouts that require half-inch-to-a-foot drawing. Each of those scale factors would mean a different seed file for each, so the border would be set to match the scale factor.

I: For each scale factor . . . if you have different scale factors, you'll need different seed files?

S: Right.

I: So you determine who the client organization is and whether you need to attach their border to the seed file. Then you determine the number of seed files per scale factor. What would the next thing be that you'd do?

S: I would start with the first seed file and set all my parameters up accordingly, such as dimension attributes, text levels, and client standards.

I: How would set the dimension attributes?

S: I'd have to read through the client's procedures first to determine their requirements and follow them.

I: Where do you read through the client's requirements? Is that in the contract?

S: Sometimes we are lucky enough to get a copy of their standards. If not, we'll go by our own standards which define line weights for dimensions and various title headers . . .

I: So, if client standards are available you use theirs, if they're not, you use yours.

S: Right.

I: After you determine dimension attributes, you said something about text. What are some of the attributes there?

S: Text sizing. Spacing, links, and even level . . . colors.

I: What are some of the things you do in setting text sizing, levels, and colors?

S: It's just a little short key-in, like "t.x. equals text height." Real short, brief, command key-ins.

I: And how do you determine what text size to use?

S: Go by the scale factor involved with the drawing.

I: So, if the scale factor is one scale, then the text is another . . . what would an example be?

S: An example would be a quarter-inch-to-a-one-foot drawing would require your text height to be set at six inches.

I: And you said something about levels. Were you talking about text levels or something else?

S: Yeah -- text levels. Set that as a default where your text is set at that level.

I: What are you doing when you're setting text levels?

S: It's another quick key-in.

I: What does that do, though, in terms of a drawing?

S: It will activate that level number to be the default or the active level.

I: Are there any other parameters you need to set . . . text levels, color, that kind of thing?

S: If it were to be a three-dimensional drawing, I'd set the view attributes.

I: So if it's a three-D drawing, set the view attributes. And what are view attributes?

S: Well, we can have the one view looking at the top plane, another view set to look at the front, another view set to the right, another view, the iso view, to get a full three-dimensional effect.

I: How do you set view attributes?

S: Turn some more views on. You only have one view turned on when you go into a drawing, so you have to turn some views on, using the mouse to pull up a hierarchical menu to activate more views and, then you would define the views, using another dialogue box.

I: What do you do to define views?

S: In the dialogue box, you can activate the view number and define a parameter to it, such as front, top, back, or isometric.

I: You determine who the client organization is and whether you have to attach their border to the seed file, you determine the number of seed files per scale factor, then you set your parameters. The dimensioning attributes are determined either by client requirements, if available, or your own requirements. You set up your text levels, your text size, your text spacing, etc. If it's a three-D drawing, you set view attributes, turning views on and defining views. What do you do after you set the parameters?

S: Well, about all you have to do from that point is save them. So they'll be active.

I: Save all the parameters?

S: Save all the parameters.

I: How do you save the parameters?

S: File -- either Control-F, which I normally do, or type in "file," or pull it off the dialogue box.

I: What do you mean by "pull it off the dialogue box?"

S: Works like Windows. You've got the file choices, you pull it down and save.

I: Using your digitizer?

S: On my machine I have a mouse.

I: Let me go through this one more time to summarize. You determine who the client organization is. You determine whether you have to attache their border to the seed file. You determine the number of seed files per scale factor. You set parameters which include dimensioning attributes, using the client's requirements if you have them, using Stone and Webster's if you don't. You set the text attributes . . . text parameters, such as the size of the text, spacing, color, that type of thing. If you're doing a three-D drawing, you set the view attributes by turning the views on, defining the views, etc. You save the parameters by using Control-F, which is what you usually do, typing in the file . . . is that the file name?

S: Typing in the word "file."

I: . . . or pulling of the dialogue box. Going back to the three-D drawings . . . how do you determine if you are going to do a three-D or two-D drawing?

S: For example, if you're going to do an architectural floor plan, what we use is project architect. It's pretty well all three-D. So anything . . . you have to use three-D with them.

I: All architectural drawings are three-D?

S: Right.

I: So, if it's architectural, then it's three-D.

S: Even mechanical . . . if we're using any duct work within a building, it has to be a three-D drawing. Eighty percent of our work now is three-D, so any we set up are three-dimensional.

I: Let me go back to determining the number of seed files per scale factor. I think we touched on this, but how do you determine the number of seed files per scale factor?

S: You only need one seed file per scale factor, it's a matter of how many various scale factors you need.

I: How do you know how many scale factors you need?

S: Well, pretty common . . . we stay within a range of quarter-inch, half-inch, and three-quarter inch. Sometimes a little different. So usually three to four will get us any scale factor we need.

I: So any drawing or set of drawings might require more than one scale factor?

S: Right.

I: And how do you know which one to use and when?

S: Luck of the draw, sometimes. Depends on how much of the drawing you need to fit, and if it doesn't fit, just create it in a different scale factor -- it's pretty quick and easy.

I: So you're constrained by the size of the output . . . the paper?

S: The floor plan, so to speak. If you have a big 100 foot building, you draw . . . the project architect will draw 100 foot long, so you may need a quarter-inch border, which is scaled up bigger than a half-inch to fit the building in the drawing itself.

I: So, typically the larger the object you're drawing . . .

S: . . . the smaller the scale.

I: So you determine the organization. The need to attach the border to attach the border to the seed file. You determine the number of seed files per scale factor, and often, the scale is determined by the size of the object you are drawing. Sometimes, in a set of drawings, you might have different scales because of different size objects?

S: Um, hmm.

I: You set your parameters, which include dimensioning attributes, which are typically determined by requirements, if available, and by Stone and Webster's if they are not. The text, which includes size, spacing, color, the levels

. . . you determine whether you are going to do a two-D or three-D drawing, and typically, if it is going to be architectural or mechanical drawing, its three-D. Otherwise its two-D?

S: Yeah.

I: Okay. You set the view attributes by turning the views on and defining the view attributes in your three-D drawings. Then you save the parameters, which can be done by typing Control-F, which is what you usually do, typing in the word "file," or pulling it off a dialogue box.

S: Right.

I: Anything else that we've missed?

S: Not that I know of.

I: Okay, great. Thanks.

Subject 2
Problem 1
Interview 1
TRANSCRIPT

Problem: "Set up the seed file(s) for a with a maximum of five drawings, one each of the following: mechanical, electrical, civil/structural, architectural, and cover sheet."

I: When did you first start to solve this problem?

S: The first or second day after we met and I received the packet.

I: And how long did it you . . . when did you finish solving the problem?

S: Well . . . between all the times I had a chance to work on it . . . a day, maybe.

I: So, it actually took you a day to work through the problem?

S: Yeah.

I: Okay. What's the first thing that you did?

S: Well, I took the problem, thought about it, and considered . . . the first thing I considered was the number of drawings that I had. There were just five drawings . . . and kind of based it on how, if you've worked at a certain place as long as I have, you kind of do it the way you've been doing it. So I figured to do it kind of like we do it now. And, if we were to get a job with just five drawings, we would set it up, or I would try to set it up as simple and quick as possible. If it were a 300-drawing package, and we get some projects like that, we'd have multiple seed files . . . cause it is worth the time to go into it. Five drawings . . . make a good, straight cut seed file. It would be pretty generic.

I: So for this one, you made only one seed file?

S: Yes.

I: Okay. So the first thing you did was consider the number of drawings. Then you determined you could make one seed file because there were only five drawings?

S: Um, hmm.

I: What's the next thing that you did?

S: Started setting it up with the different parameters . . . that we do.

I: What's the first thing you did to set up the parameters?

S: Well, the first thing we did was set up locks. Usually the only lock we set is a "snap lock."

I: What is a lock?

S: Like you if you turn a grid on in a drawing, you can turn your grid lock on and it will snap to points in the grid. You can draw lines to grid points . . . without having to do anything special. And if you've got a snap lock on, you can snap to the ends of lines . . . it will go straight to the ends. You don't have to do any calculations or anything else; it will just automatically shoot to the ends of lines.

I: So the first thing you did was to set up a lock. And, again, why did you do that?

S: The snap lock, or the basic locks we use, are . . . for ease of drawing. Basically, all of this . . . everything a seed file consists of is to make your easier, initially, to draw. And, uh, you can also set up . . . which also has to do with your locks . . . a key snap, which gives a number of points it will snap to a line. If you have one line, you can divide that line up into a hundred points if you want to. So you can set a snap to any number you want to, and we always set it to "two." So it will snap to the middle of the line if you want to snap to the middle.

I: Okay. Why did you set it to snap to two rather than any other number?

S: That's pretty basic . . . the mid-point of the line is what we use a lot of times.

I: Okay, but what is the logic there . . . why is it good to set it to two rather than any other number?

S: There really isn't any . . . it is just . . . all the experience we have . . . if you want to move objects, and you want to center them, on another object, you just snap to the edge of a box, it will snap to the center of the edge of a box, and if you have a box that's bigger, that you want to center it on that box, you snap to the center of that one, and it will center it automatically. And you can set it up a hundred times and you can draw a hundred lines evenly spaced on one line.

I: You mentioned "we set it up," is that standard operating procedure for Stone and Webster?

S: Yes. It's usually . . . it's what we, in this office, like to do. A lot of this stuff, the way I set it up is the way we like to do things which comes from experience -- what works faster and actually . . . this office is probably setting most of the precedents in this company in Intergraph. Because we do most of the work in Intergraph, except, maybe, one or two offices in the entire company. So, we don't follow anybody's rules. Since we've started, we more or less make up our own.

I: So you guys are setting the standards?

S: Um, hmm.

I: You mentioned that, in setting up the parameters, one of the first things you do is set up the locks. Why is that one of the first things that you do?

S: Because that's . . . there really doesn't have to be any specific order. It's just one of the first things I come to. You just want to make sure you take care of everything.

I: So for you . . . in this particular case, did you follow a set order for setting up your parameters?

S: Not really . . . it's just . . . most of it's in my head.

I: So you might set up your parameters in a different order for every set of drawings that you do?

S: Uh . . . you could.

I: But how about you . . . do you usually use the same kind of order every time you do a set?

S: Usually, yeah.

I: And why do you use the same order?

S: It's just from repetition. It doesn't matter what order you do things in a seed file, as long as you get them all.

I: What did you do in this set of drawings? What did you do after setting up the locks?

S: I usually set the grid.

I: Is that what you did in this one -- set the grid?

S: Yeah. I set a certain grid spacing.

I: And what is "setting the grid spacing?"

S: Well, you set . . . I was telling you have points . . . you set up those points . . . you usually set them to an eighth-of-an- inch.

I: Is that what you set them for in this case?

S: Yeah.

I: Why did you set them to an eighth-of-an-inch?

S: Because that's . . . it's not too much and it's not too little. You don't want to get down to a thirty-second or a sixty-fourth . . . usually, what we do, you don't even go to an eighth -- it's usually a quarter.

I: How do you determine to go to an eighth or a quarter?

S: From experience. When we get drawings . . . especially architectural drawings, we rarely get anything incremented any further than an eighth . . . you may get a sixteenth, but if a carpenter was to look at a sixteenth-of-an-inch, they'd probably just laugh at it.

I: So, for a lot of your work, especially if it's architectural, you don't go lower than an eighth-of-an-inch on your grid, and that's the case you used in this one?

S: Um, hmm.

I: So, what does . . . does that have to do with the scale of drawing?

S: No.

I: Is your scale one-to-one . . . is that how you set up this seed file?

S: Yes. You do your drawing "real-world," if you draw . . . if it says it's an inch long, you draw it an inch long. And then you can set your scale up according to the border. You make your border however big it needs to be to give you your scale.

I: So the first thing you did was consider the number of drawings, and when you determined there weren't a great number, you decided to make one seed file for this problem because of the small number. Then you set up your parameters, and the first parameter you set up was the lock,

or locks, then you set the grid. What was the next thing that you did?

S: You have what is called "view attributes."

I: What are they?

S: Those are how your screen displays objects. Like you can turn on . . . you have curves . . . you have what is called a "fast-curve display" . . . if it's on "slow-curve display" it will show a curve. If you show a fast curve, it won't take as long for the screen to regenerate . . . the curve will show "notched" -- it will look like straight lines.

I: The "jaggies?"

S: Yes. And, if you have a real huge drawing, you can control your view attributes to control how long it takes for a drawing to regenerate.

I: For this particular problem, how did you set the view attributes?

S: Set for the high resolution . . . our machines are pretty fast . . . we normally don't get into a drawing that requires the fast display.

I: So for this particular set of drawings you set the curve attribute to high resolution because it doesn't take long for the computer. What other view attributes did you set?

S: Text nodes . . . which is a little node that you can place text on . . . you just place them in your drawing . . . or whenever you do a paragraph of text, it makes a text node. It's a number that initializes that piece of text.

I: So it's not the text . . . the text actually doesn't show on the screen, just the number?

S: No, it's vice-versa. You can show the number and the text, it's usually where the origin of the text is at . . . that's where the numbers at. It's like if you put . . . the first piece of text you put in, if its a paragraph, it's number one. And if you put in another, that's number two. And it will number all of those. And you can place them "one, two, three," or you can place the text and it will automatically number them for you. Those little numbers, we turn them off because we don't want them to plot.

I: Okay. You just want the text. Why do you use text nodes?

S: I usually don't. But there's nothing you can do to keep it from automatically making text nodes. Because when you make paragraphs, it will automatically make nodes for you.

I: In this particular seed file, did you have text nodes turned on or off?

S: Off . . . so they will not plot.

I: So, for view attributes, you set curve resolution to "high," but you turned text nodes off. What other view attributes did you set?

S: Enter data fields . . . which you can place text and change text . . . they're underbars on a typewriter . . . they're shown as underbars, and you can place text inside there, and you can hit it and change it and do anything you want to it.

I: Why did you use those?

S: To place text . . . in a certain point. Like if you make, what we call a cell, then you can place data fields . . . in a typical drawing, you may have a typical detail with different settings on it, like you may have an eighth-inch weld, or a sixteenth-inch weld, you would put a data field there if you wanted to change the weld size. You could place the cell in your drawing, and there would be no text there . . . there could possibly be no text on it. And then you just pick the data field and place the text in yourself. It's already in a pre-set spot . . . like you the text in a certain spot.

I: Does the data field change when you change different . . . like if you change one dimension, all of the other dimensions change?

S: No. You have to do that manually. And it's not actually dimension-oriented, it's just text-oriented.

I: Did you set your data fields "on" or "off?"

S: I turned them off. But, we have eight views in Intergraph, and we also have two screens. On the first screen we have view one . . . and that's another view attribute we set, what views we show . . . you can flip screens and show view five. In view five, we have the opposite -- it's either on . . . like the data fields will be on . . . you can go into that view and see them and fill them in, but you plot from view one.

I: Why do you plot from view one, but have the ability to view the things in another view?

S: So you don't have to go back-and-forth switching these things. You can leave them on in view five . . . the things you don't want to plot, but that you'd like to see . . . you can leave them on in view five, then you can switch to view one and they'll be off.

I: Is that what you did in this problem? In view five you had stuff turned on, and in view one you had things turned off?

S: Right.

I: View one was the stuff you were plotting, view five was the stuff that you'd refer to, but why would you refer to it in the first place?

S: Well, if you had it turned off . . . like an enter data field . . . you can't see it.

I: Why would you want to see it?

S: So you could put text in it?

I: Why would you want to put text in it?

S: If you have a data field, it shows as underbars. If you put text in it, the underbars still show . . . and text shows and the underbars show, and you don't want the underbars to show. That's what it turns off. It doesn't physically turn off the text. The text remains.

I: What does the text tell you?

S: Anything you want it to tell you. Like, if you've got a detail and you put, say, four-mil polyethylene, and in another detail . . . you may have the same, exact, detail, but you want four-mil polyethylene in this detail, but you want six-mil in another detail. You would leave a data field there so you could type in "four-mil" in one, and "six-mil" in the other.

I: Who ultimately reads the "four-mil" or "six-mil" type of detail?

S: You plot them and an engineer reads them and checks them, then it goes to the client.

I: When you plot it in view one, but you plot out view five for the engineers?

S: No. No. The data fields, like the text nodes, are system-oriented. It shows you the data fields . . . the underbars, so you can fill text in, but you want to turn the underbars off, and leave the text in. So in view five, you can see the underbars, cause if you have them turned off, you can't see the underbars. But, the text still shows.

I: So when you plot it, you plot the text, but not the underbars.

S: Right.

I: In this particular problem, when you made the seed file, did you put some text nodes and data fields in, or did you set it up to do one or the other?

S: Just set it up to do that. Because you know it will work out that way.

I: So you set up view one to have the text nodes and data fields turned off, but you had them turned on in view five?

S: Yes.

I: What about the other four fields, like two, three, four, and six? How did you . . . did you have them turned on or off?

S: You mean the views?

I: Yes.

S: Usually don't . . . if the operator wants to open up another view, they can change it any way they want it.

I: But typically you look at only view one and view five?

S: Usually. Because . . . you can open up more views if you want to . . . that would be operator preference. You try not to anticipate . . . that's one thing -- the seed file is generic, so you don't try to anticipate any particular operator preference. If they want it a certain way, they can change it. But it's usually a general set-up.

I: So, when you set up a seed file, you're not turning on or off the other views, those people can see the other views. But when you're setting up the seed file, you're only concerned with setting up one with text nodes and data fields off, and five with one way or the other?

S: Um, hmm.

I: And in this particular case, you set the curve to high resolution, the text nodes to "off," and the data fields to "off" in view one . . .

S: Um, hmm.

I: . . . and in view five you did the opposite . . .

S: Um, hmm.

I: Then the other four views you didn't set it up at all?

S: Um, hmm.

I: What other view attributes did you set up?

S: There's a bunch . . . there's several. You can turn your dimensions "on" or "off." That's for speed.

I: What did you do in this particular seed file?

S: Left them on in both views. Because you want your dimensions on anyway. Like I said, these machines are fast, and you don't have to worry about that. And you can turn patterning "on" or "off." Like "earth patterning" or "concrete patterning" . . . you can turn that on or off. You usually leave it on.

I: That's what you did in this case?

S: Yes. And we have reference file clips -- we usually leave that "off."

I: What is a reference file clip?

S: Do you know what a reference file is?

I: No.

S: That's a file that's brought in as a background to the other file. You can be working in one file and bring in a floor plan that if you're on the second floor, you can bring in the first floor plan and see what it looks like under there.

I: Like an overlay?

S: Yes. And you can take parts of that out . . . clip out parts that you don't want to see. And you can leave it in your drawing and plot it. That's what we usually do -- if you have a first floor plan and the second floor plan walls

are the same . . . we usually use the first floor as a reference file and draw stuff on it.

I: It's almost like a batch file -- you have a picture, and you just work from that rather than re-do . . .

S: Right. You don't have to re-do it. And that's what the beauty of Intergraph is -- you don't have to update ten drawings if it has that one file . . . you can update that one file, and all the other drawings will be updated. And you can cut out sections of that, if you don't want part of a wall here, you can take it out. But, if you do that in a bunch of different places, you don't necessarily know where you've done it. So, that's why that reference file clip display . . . you can show yourself where you've clipped it out. And you don't always want to see that, so you leave it turned off.

I: So in this particular case, did you turn the reference file clip display off?

S: Off.

I: All views?

S: Yes.

I: Why did you do that for this particular set of drawings?

S: That's usually the way we set it up.

I: That's standard operating procedure and that's why you did that?

S: Uh, huh.

I: What else in terms of view attributes? Any others?

S: No.

I: Let me just go through this again. The first thing you did was consider number of drawings, and you determined you had only a small number of drawings, therefore, you made only one seed file for all five drawings. You set up the parameters which includes setting the lock, setting the grid, and setting the view attributes. The view attributes included setting the curve to high resolution, setting text nodes off in view one but on in view five?

S: Um, hmm.

I: The data field off in view one and on in view five, dimensions on in both, patterning on in both, reference clip file off in both?

S: Um, hmm. There's also a grid display you can turn on or off, and I turned in off. You set up the grid so an operator can use it, all they have to do is run over and turn it "on."

I: Okay. Why did you turn it "off?"

S: Because most operators, in these particular types of drawings, don't use it. Mostly we use grids in P and ID drawings.

I: What is "P and ID?"

S: That's a piping schematic type of drawing. Some people use grids in all their drawings, but that goes back to operator preference.

I: What did you do after you set up the view attributes?

S: Well, we also have dimensioning attributes -- a lot of operator preference on that. The important thing with dimensioning attributes is that we set up our terminators for our dimension arrows to a certain symbol . . . we have a certain symbol that we use.

I: What symbol did you use in this one?

S: Just a filled-in arrow. Intergraph's default is an open arrow, and those are pretty ugly.

I: You did that because of personal preference or because it is standard operating procedure?

S: That's standard for this office. And you can set the dimension text below the line, above the line, or split the line. I set it above the line.

I: Why did you set it above the line?

S: That's where we put all our dimensions. We can also set the weight of the dimension lines.

I: At what did you set the dimension weight?

S: Zero, which is a real thin weight . . . and the text and the dimension lines to a weight of "one," which is just a little bit heavier. The text will stick out from the lines,

and that's drafting procedure there . . . that's standard drafting procedures there.

I: And you did that for this seed file?

S: Yes.

I: Any other dimensioning attributes?

S: That's all I set up. And you have text attributes, which are usually pretty simple. There's a certain font we use . . . a font of one. It's just how the text looks . . . you have Greek fonts and Old English fonts, font one is just the standard font we use. That's our standard operating procedure. A font of one, with the text origins at the upper left-hand corner.

I: What do you mean by text origins?

S: Like when you place the text in a drawing, your text, where you place it, will be in the upper left-hand corner. That's standard.

I: Did you do that for this seed file?

S: Yes.

I: What did you do after you set up text attributes?

S: That covers everything that we take care of.

I: And that's what you did in this particular project?

S: Yes.

I: Okay. Let me just summarize, real quick, what you did. The first thing that you did was consider the number of drawings. You made one seed file because you determined that five was a small enough drawing to make one seed file. You set up the parameters, which included setting up the locks, and you do that because it's easier to do the drawing -- it's kind of a batch file. You set the grid, and you set the grid in this case to one-eighth inch. The reason being that, for these types of drawings, that's standard procedure. You set the view attributes, and that included setting the curve to high resolution, text nodes off in view one and on in view five, data field off in one and on in five, dimensions on in both, patterning on in both, grid display off in both, reference clip display off in both. Then you set the dimension attributes, which included things like arrowheads, and the reason you chose the type arrowhead you did was because in this office you guys determined this

is the better-looking type of arrowhead to use. You set dimensioning above the line. Why did you do that?

S: That's our standard.

I: Then you set text and line weights. Text is a weight of one, line is a weight of zero. You did that is because it is standard drafting procedure. Then you set text attributes to one which is another Stone and Webster standard. Is that everything?

S: You also set text justification . . . where the origin is.

I: Upper left?

S: Yes.

I: And that, again, is Stone and Webster's rule-of-thumb.

S: Yes.

I: Okay. Thank you very much.

Subject 2
Problem 1
Interview 2
TRANSCRIPT

Interviewer: Okay, you've looked at the expert system program and the hypertext program. I'm going to interview you on the same problem, asking you how you would solve the problem if you were to have that problem a second time. What is the first thing that you'd do in setting up the seed file or files?

Subject: Basically, just see what the job required . . .

I: What do you mean by "seeing what the job requires?"

S: See if they have any specific standards. If you have to go by a company's standards, or if you can just use Stone and Webster's corporate standards.

I: How do you determine whether to use the client's standards or Stone and Webster's?

S: Basically, when you start the job, you know who the client is you're starting the job for, you ask them, first, if they have CAD standards. If they don't, they normally give you the free hand to do it your way, so that's when we'd incorporate Stone and Webster's standards. If they have their own CAD standards, we just have them send them to us, and we use those.

I: So, if they have standards that they'd make available to you, you use the client organization's standards, and if they don't you use Stone and Webster's standards.

S: Um, hmm.

I: What do you do after you determine which standards you're going to use?

S: Then you can begin setting up your seed file. With a small number of drawings like that, you'd probably use only one file.

I: So you'd set up your seed files, or file, and, again, using the parameters of this problem, there were five drawings, so you set up only one seed file. If you have quite a few drawings, would you set up more than one?

S: Probably, because when you have a case, like different drawings . . . electrical, mechanical, you usually do have different parameters for your files. But with a small job

like that -- just five drawings -- you would set up one seed file and each person could go in and, there's usually just small changes . . . in dimensioning, or grid, or . . . something just minor. If you've got a whole lot of drawings that are going to be in it, it would be worth the time to go ahead and just set up a seed file for each discipline.

I: So you determine the standards, you set up one seed file -- you determine that if there are only five drawings, you set only one seed file. What's the first thing you'd do to set up that one seed file?

S: You'd go in, open up the seed file, then -- there's not any specific order -- you'd attach the border for that particular job. And set up your text fonts . . . and you could set up your dimensioning attributes, how you want those to come out . . . you have specific line weights for lines, and specific weights for the text we use.

I: Are those Stone and Webster standards?

S: Yes. Those are basic . . . those are kind of drafting standards . . . pretty basic, even among corporations.

I: If drafting standards exist, you'll use the drafting standards. What if drafting standards don't exist for some of these dimensioning attributes? What do you default to, then?

S: A lot of it would be . . . what we try to do . . . we would like to have user preference. How the user would like to do it. But if you do that, you have inconsistent drawings. So we usually determine one way to do it . . . if there's a gray area, everyone gets together and determines how they're going to do it, and everyone agrees to do it the same way.

I: So, if no standards exist, for a dimensioning attribute, the workers at Stone and Webster get together and come up with a de facto standard?

S: Right. And everyone goes back, because that's the last thing we want -- inconsistent look in the drawings.

I: You mentioned when you open a seed file and set up attributes, there's no specific order. What order do you use? What order would you use with this problem?

S: Probably the order I'm giving you.

I: The order you've given so far is: attach the border, set up the text fonts, set up the dimensioning attributes. Why do you use that order?

S: It's just what you're used to doing first. The reason it doesn't matter what order is because none of it's tied together to where you . . . it's not where you have to go in, like working on a car, to get to a piston you have to take the head off first. It's not dependent on an order. It's usually just whatever you think . . . you're sitting at your desk, and you think, okay, I have to do this . . . and you just do it. I need to do that, so you do that. Sometimes you even do it different yourself . . . in different order. So, just whatever you decide to do.

I: So, if the parameters you're setting up are not interdependent, then you can use personnel preferences in setting up.

S: Um, hmm.

I: Just to summarize what we've got so far: you determine what the job requires, in terms of whether you're going to use client standards or Stone and Webster standards. Then you set up the seed file. You determined that with this number of seed files, five, you're going to set up one seed file. Is there a cut-off point at which you'd look to set up more than five, or is it dependent on the type of drawings or . . . how does that work?

S: It would depend on the type of job. Sometimes we get just like a mechanical job, and most of it would just be dependent on minor mechanical drawings. And sometimes we get jobs that have everything in it.

I: So, if it's all mechanical, regardless of how many drawings you might have, you'd set up just one seed file?

S: Correct.

I: But if it's a number of different types, you might set up a number of different seed files?

S: Um, hmm.

I: Then you open the seed file and set up your attributes. Those attributes are not interdependent, so it's a matter of your personal preference and, typically, you attach the border first, set up text fonts, and set up dimensioning attributes. Both your text fonts and dimensioning attributes depend, most of the time, on drafting standards. Most companies use the same standards.

S: Um, hmm.

I: However, when those standards don't exist, Stone and Webster employees get together and determine de facto standards so the drawings have some consistency.

S: Um, hmm.

I: What would you do next to solve this problem?

S: Set up our locks. Set up certain locks.

I: Explain that.

S: It's usually . . . a lock is just a . . . one lock is just a snap lock, which is something we always have on. You can make a point on the very end of the line that snaps to the end of the line, which is very simple and basic, but is very handy. If you want to place a line from the end of another line out so far, you just can snap to the end of that line without having to do anything special, to go exactly on the end of that line.

I: So, you set up locks, and one of the types of locks is a snap lock. And one of the reasons you'd set up a snap lock is for more accurate line drawing?

S: Um, hmm.

I: What are some of the other locks?

S: We have, another thing that's tied in with the snap, is the key point number. You would put it in . . . standard is key point "2." It divides a line up in two places. So you can key in any number: two, ten, twenty . . . it will divide that line you're snapping to into segments. So if you want to draw from the middle of a line, you key in "2" and it will snap to the center. You usually use that . . . that's always saved, we usually save that. So, it will be in the seed file.

I: You do that so you can more accurately draw from the mid-point or wherever you might want to draw another line . . . another 90° from?

S: Right. And we always have our text node locks. That's a display attribute; that's not necessarily a lock. We don't worry about the display attributes. A snap lock are usually the only ones to save. Some of the other locks are user preference, and if they want it on their particular drawing, they can set them up in their own drawings. But the seed file really doesn't have anything to do with another drawing

. . . it's just like a copy of something . . . underlying standard . . . like a basic . . . like if you have a basic program, and you want to take out a part and add your own to it, that's basically what a seed file does.

I: What does the text node refer to?

S: That's in the displays . . . that's another thing we want to set up, is our display attributes. Display attributes . . . you'd have text nodes would be "off." Like I said, each time you want to place a paragraph of text, there's a number associated with that paragraph of text . . . it's called a text node. If you have your text nodes "on" it shows that little number, and you don't want that little number to plot. All it is . . . it's intelligence to the text. You can key in that text node number and do things . . . do certain things to it. But you don't want that to show, you want that to disappear. So you turn that off in your drawing. And you turn those off . . . and, usually, you leave the grid off, too. You can have a grid, and you can set up for certain spacing. Leave the grid off. That's just part of the display. And your curves . . . you want what's called "fast curves" . . . and fast font, which doesn't show the font chalked-up, it doesn't show the curve chalked-up. It displays faster than if you have the slow curves, and the curves instead of being a curve, it looks like lines. That's just for faster display. But you don't want it to plot like that. You want it to plot a curve as a curve.

I: Some of the display attributes are for efficiency, so the screen refreshes pretty quickly and you don't have to wait for it to plot on the screen?

S: Right. But we usually . . . that only comes into play, computers have gotten so fast and it takes a pretty big file for you to need to do that. So that's why we always set up our seed files showing it the way it's supposed to be.

I: The rule here would be "If it's a large file that would take a long time to refresh on the screen and display, you'd use that attribute where it would show lines rather than the smooth curves." But typically, you guys use the smooth curves.

S: We rarely get a design file that large. Like I said, the computers we have now are pretty fast. We don't normally have to worry about that.

I: Is it critical about when you set up the display attributes, or is that one of those things where you can set it up . . .

S: All of it is in no particular order.

I: Okay. So you determine the client's standards or whether you'll use Stone and Webster's standards. You set up the seed file; for five drawings you set up only one. You open the seed file and attach the borders. Set up the text fonts. Set up the dimensioning attributes. Set up the locks and display attributes. What would you do next?

S: That's pretty much got it for the seed file. Everything else, basically that's how the user wants to do it. What the seed file does, is it just gets you started.

I: Very good. Well, I sure appreciate your time.

Subject 1
Problem 2
Interview 1
TRANSCRIPT

Problem: Design a 3D office layout within a 12 x 14 foot office.

I: When did you first begin to solve the problem?

S: Yesterday.

I: When did you finish it?

S: About ten minutes ago.

I: About how long did you work on the problem?

S: Probably an hour, at the most.

I: What's the first thing that you did?

S: Well, I thought, "this is my office, I'll do it right."

I: So the first thing you did was assume it was going to be for you? (Subject shakes head affirmatively) What's the next thing that you did?

S: Well, I like a lot of light so I allowed a curtain wall along the other side . . . put a bunch of windows in one side.

I: Okay. And you did that because you like a lot of light?

S: Yeah. It keeps me happy.

I: After you designed the windows on one wall, what was the next thing that you did?

S: The type of lighting . . . I had to arrange the lighting.

I: Overhead lighting?

S: Uh huh.

I: And how did you do that?

S: I ran it across the narrow part of the office -- perpendicular to it . . . parallel to the narrow dimension, twelve feet.

I: And why did you run it across the narrow dimension of the office?

S: So the light would disperse better and be high on the walls.

I: Did you use any particular kind of lights?

S: Recessed incandescent.

I: Why did you use recessed incandescent lights?

S: That's just my favorite.

I: Personal preference?

S: Um hmm.

I: What is it about recessed incandescent lights that you, in particular, like?

S: Just flush . . . I don't like them protruding down.

I: Okay. After you designed the lighting, what did you do next?

S: Determined the type of furniture I need.

I: Okay.

S: A desk, reference table, filing cabinet, bookshelves.

I: Desk, reference table, bookshelves . . .

S: Filing cabinet.

I: Okay, what else?

S: Of course, telephone, computer, printer.

I: Is that pretty much it?

S: Yeah.

I: Any particular kind of desk?

S: Executive desk.

I: And why did you choose that kind of desk?

S: Personal preference.

I: What is it about an executive desk that you personally like?

S: It sets off the image that I know what I'm doing.

I: Alright. And what is a reference table -- I'm not familiar with that term?

S: Just, really a table with no drawers or anything in it . . . to lay stuff out, spread papers out.

I: Okay. When you designed this office for yourself, did you assume that you'd still be doing the same job you have now -- design work, that kind of thing? What would you be doing if you had this office?

S: Systems Administrator.

I: And, so, when you're using a reference table, you're using it as a Systems Administrator . . . "big shot" kinds of things?

S: Yeah.

I: You mentioned bookshelves. Why would you need bookshelves?

S: Reference manuals.

I: Is that something a Systems Administrator would have a lot of call for?

S: Um hmm.

I: File cabinet . . . how many drawers would your file cabinet have?

S: At least four.

I: And . . .

S: Lateral.

I: Lateral file rather than a vertical file. Why would you pick lateral rather than a vertical file cabinet?

S: They hold more and they . . . well, they take up more room along a wall, but they're not near as deep as far as sitting on the floor.

I: Okay. And you'd have a phone for communications. What would you use your computer and printer for?

S: Writing and printing up reports, database entry, loading in . . . corporate communications.

I: When you did the design of your office and put the furniture in, did you size the furniture in relation to the size of the office?

S: Yeah.

I: For instance, what size would your executive desk be?

S: I didn't measure it.

I: So you didn't measure it, but you actually placed it on your drawing?

S: Yeah.

I: What was your thought process when you placed the furniture -- why did you put the furniture where you put it?

S: Well, again, that's why I was concerned about the lighting. I'm the type of person that kind of likes it diagonal . . . so that things sit diagonally to reduce the amount of shadow you project on your table. So I put it diagonally.

I: So, like kind of coming out of a corner rather than flush against a wall, that kind of thing?

S: Um hmm.

I: Where did you put your desk in the office? Did you put it in a corner or against a wall?

S: It sits diagonally.

I: I notice your door is set very close to one of the walls. If you walk straight through the door back to the corner opposite along the same wall as the door, you'd come to the corner of where that desk is.

S: Right.

I: So if your door . . . let me see how this would work . . . southwest corner, your desk would be in the northwest corner.

S: Right.

I:Why did you put the door where you put the door?

S: No particular reason. I'm left-handed when I reach for a door handle. So when I reach for the door handle with my left hand, I push to the left.

I: Where would you put your reference table?

S: Right back here.

I: So it would be right . . .

S: No . . . that's my filing cabinet -- I made a mistake. The reference table is right here.

I: Your reference table is approximately center of your eastern wall, your file cabinet is approximately the center of your southern wall. Why would you put those where you have those?

S: I like that arrangement.

I: Personal preference?

S: Yeah.

I: How about your computer and printer? Do those go on your desk, or . . .

S: Yeah, on the desk. Laptop.

I: A laptop! So, you can carry it with you. Why would you choose a laptop?

S: Pure convenience. More desk space.

I: So the first thing you did was make an assumption that the office was going to be for you, that you would be a Systems Administrator. The first thing you designed was the full wall of windows along the northern wall. The next thing you did was the overhead lighting which you ran across the narrow dimension of the office, and you did that for dispersion of the light. You decided to use recessed incandescent lighting which is flush to the ceiling, which is your personal preference -- to have lighting that's flush. Then the next thing you did was determine what kind of furniture to put in your office. And you included an executive desk because of the image it projects, the reference table for spreading out your work, bookshelves to hold your reference manuals. Where on your drawing did you put your bookshelves, by the way?

S: On this wall.

I: So, about the center of the west wall -- not quite the center of the west wall. Your filing cabinet would be at least a four-drawer horizontal rather than vertical file cabinet. Then you'd have the phone for communications. You'd have a computer, which would be a laptop so it would take less space. You'd have a printer so you could print reports, use it for database input, and modeming. What did you do after you determined what furniture you wanted?

S: That's when I placed it in . . . got the right arrangements.

I: I notice you have a hand-rendered drawing here. Did you do only sketching to design this or did you . . .

S: This is my preliminary sketching, and I did it on a computer.

I: Oh, you did do it on a computer, as well?

S: Uh huh.

I: What computer program did you use?

S: Intergraph. Project Architect to print the walls.

I: Why did you use Intergraph?

S: That's about all we use . . . I'm most familiar with that software.

I: When you took the preliminary sketch and put it in the computer, what's the first thing that you did?

S: Well, I already had a project started, so I just created a new drawing in that project.

I: Created a new drawing in an existing project. Why did you do that rather than start a new project?

S: Since there's really only one quick design, I didn't want to go through the procedures of creating a new project which entails time and tying a database to it. So, it just cut down on time.

I: What was the first thing you did to render the drawing, itself?

S: Laid out the walls and set out all the variables. Laid out the square room and laid out the curtain wall in the north end of the room. Then put the door.

I: So, in the actual drawing, you laid out the walls first. Then you put the windows. Then you laid out the door. What did you do next?

S: Attached the cell library where all the model furniture is.

I: Okay. Then what did you do?

S: Went through and found the desk and reference table and all the furniture I like. Executive desk, lateral file cabinet.

I: What did you do after you picked out all the furniture?

S: I placed them in. Then, once I had them all in, I could move them around and rearrange them the way I wanted.

I: Okay. What kind of considerations did you use when you placed the furniture?

S: Well, lighting, for example . . . diagonal. Pure convenience of coming in and out. Room for the chair to roll around and people to come in.

I: So, you placed the furniture, then what did you do after you placed the furniture?

S: I modeled up the walls. Played around with it a little bit.

I: What does "modeling up the walls" mean?

S: Well, when you initially lay out the walls it's on a flat, 2D plan. So you have to go through a little series of commands to cut a section and an elevation of a building, then it will project them up.

I: Then after you modeled up the walls, what's the next thing you did?

S: That's about it. Spun it around and looked at it.

I: So, you looked at it?

S: Yeah. Shaded it and all that.

I: What do you do when you shade a model like that?

S: You arrange the wire frame in a good looking angle to look at, and then just pull the render dialogue box and tell

it what kind of shading you want: shaded, stereo, full hidden line . . . there's various types.

I: Which way did you shade it?

S: Full hidden line.

I: Why did you choose that?

S: That still leaves the image. You can still see the edge of the walls and the corners of the walls, and the wall coloring. So you can still see the image.

I: So, that's the last thing you did, the shading?

S: Um hmm.

I: Well, thanks very much.

Subject 1
Problem 2
Interview 2
TRANSCRIPT

I: I'm going to ask you about the same problem you solved originally -- that you need to design an office. What is the first thing that you'd do?

S: Given the criteria of the sizing, I created the design file in "Project Architect?"

I: Why would you create a design file in "Project Architect."

S: "Project Architect" is the environment in which we design floor plans, and so forth . . . and the design file is the actual design itself.

I: So, the design file is basic to the creation of the rest of the design?

S: Um, hmm.

I: What goes into the creation of the design file?

S: Anything and everything -- all the walls, windows, doors, furniture . . .

I: What is the first thing you'd do in creating the design file?

S: Enter through "Project Architect" and create a design file.

I: Okay, how would you create a design file? What's the process that you'd use?

S: Once you get into the "Project Architect" environment, you have several menu options. One is to create a design file. Fill in the file name, and it will make it.

I: Okay. So you fill in a file name and it creates a file. What do you do after you create the file by typing in the name? What's the next step?

S: The computer creates it, then you have the choice of going on and entering into it.

I: What is the first thing you'd enter into the design file?

S: Start making the walls, given the criteria of the 12x10.

I: Okay, so the first thing you'd do after the design file is created, is to create walls for a ten foot by twelve foot environment.

S: Um, hmm. Assuming four inch thick walls.

I: Okay. Then what would you do?

S: I'd pick the command to pick walls by shape. Because in essence, you can draw a square . . . two-point square.

I: So, you click two points on the computer screen . . .

S: Diagonal points being ten by twelve foot apart, so I could put one point anywhere and the next point I would key off ten dimensionally ten feet in the x direction and twelve feet in the y to a diagonal point will make a ten by twelve room.

I: And you do that by using a digitizer?

S: Um, hmm.

I: Is there a grid on the screen that you snap to? Is that how you create the points?

S: Um, hmm.

I: After you create the walls . . . are you creating a floor plan or elevation at that point?

S: Floor plan.

I: What do you do after you create the walls by finding the x and y coordinates?

S: Locate the doors and windows.

I: What process would you use in determining how to design the doors and windows into the office?

S: I particularly like to place a three-foot door?

I: Why a three-foot door?

S: Roomy. I hate small doors.

I: Where would you place that three-foot door?

S: In the corner . . . to provide more wall space for one thing and . . . usually opposite the wall with the windows.

I: Which wall would the windows be on?

S: Depending on what the exterior wall was, but I assumed it to be the ten foot wide north wall.

I: So, you made an assumption that the window wall . . . the exterior wall, would be the ten foot wide north wall, therefore your door would be a three foot door on the south wall . . .

S: Southwest corner.

I: What would you do after you locate your door and your windows, what would the next part of your design be?

S: Play with some furniture layouts by attaching a cell library with all the furniture in it.

I: What is a cell library?

S: Its a file that holds all the symbols for desks and chairs and other . . .

I: So, if the cell library has the graphics of the furniture already drawn, you just choose the furniture you want?

S: Right . . . like to place.

I: How does that work? How do you actually pick furniture from the cell library? Do you open a file and see all the pictures?

S: You can do what they refer to as "show library," which is your cell library attached, and it will show graphic representations of each cell. It works a lot like "Windows." You scroll through and pick one and it will show it to you.

I: When you see a picture you like, what do you do then?

S: Select it as the active cell and insert it.

I: So, you choose it via the digitizer and insert it into the drawing. Do you make a conscious effort to place the picture where you want it, or just bring it into the drawing and drop it?

S: I generally get it reasonably close.

I: Do you continue to do that process until . . .

S: The office fills up.

I: So, you see how large the office is and that determines how much furniture you put in?

S: Um, hmm. I furnish it with what I want, first of all.

I: Okay. What are the assumptions you're making about what kind of office you'd want?

S: I'm assuming its for me later on in my career in a management position, so I kind of select furniture that would allow me plenty of storage room, yet versatility . . . like for computer equipment.

I: Let's talk about what type of furniture you'd populate the office with. What would you put in there?

S: Nice desk and a comfortable chair.

I: What is your definition of a nice desk?

S: Good storage capability.

I: Okay. What's good storage capability?

S: Center drawer and both sides, drawers.

I: How do you define a "nice chair?"

S: Supportive . . . back supportive . . . maintain my load.

I: What else would you put in besides a desk and a nice chair?

S: I find that a lateral file cabinet might take up more wall space, but less floor space away from the wall that is helpful and has plenty of storage.

I: You'd choose a file cabinet, and the reason you'd choose a lateral file over a vertical file is because it takes up less floor space?

S: Away from the wall, in that direction.

I: Okay, you've got a desk, a chair -- a good supportive chair -- a lateral file cabinet. What else would you put in terms of furniture?

S: Bookshelf, to hold reference manuals.

I: Any particular size of bookshelf?

S: Four by six.

I: Why that size?

S: Hope to need a lot of reference manuals.

I: What kind of reference manuals would you put on your bookshelf?

S: Well, based on what I'm hoping to get into, mostly computer type reference manuals.

I: What kind of assumptions are you making about what type of computer programs a manager would use?

S: Definitely going to have to have "WordPerfect." And probably some kind of tracking software; maybe even "Lotus."

I: Spreadsheet?

S: Um, hmm.

I: Anything else?

S: Other than project planning and "Lotus" and "WordPerfect," not right off the bat.

I: Okay. Any other furniture other than the desk, the chair, lateral file, and bookshelf?

S: Yeah, have to have a guest chair.

I: Why would you need that?

S: Meetings.

I: Anything else?

S: Maybe a board to hang on the wall.

I: Like a white board?

S: Yes.

I: Let me summarize what we have so far. In designing your office the first thing you'd do is create a design file in "Project Architect," and you'd create that design file by clicking on the menu item in "Project Architect." "Project Architect," as I understand it, is an "Intergraph" application. "Intergraph" is the CADD program you guys use at <company name>. The first thing you'd add are your walls, then your windows, doors, and furniture. The walls would be for a ten by twelve foot environment and four inches thick. You'd locate your doors and windows next.

You'd like a three foot door because you like a nice, wide, door. You'd place it in the corner of the southwest wall, because an assumption your making is that the north wall is the exterior wall and you want to place windows in that wall. The next thing you'd do is lay out your furniture via your cell library. The cell library is a library that has furniture already drawn in it and you can click on the pieces you want and place it in your design. Your desk would be good size with good storage. It would have drawers in the middle and on both sides. Your chair would be a nice chair. It would be supportive -- it would have a supportive back. You'd have a lateral file cabinet. The reason you'd have a lateral file rather than a vertical file is that it takes less floor space coming from the wall -- it takes more space width-wise, but less coming vertically from the wall. You'd also have a bookshelf for reference manuals. The bookshelf would be four by six. The reference manuals would be software documentation that you'd use as a manager including "WordPerfect," "Lotus," and a project planning software program. You also want a guest chair for meetings and a white board. What would you do after you've populated the office with furniture?

S: I would project the walls into 3-D.

I: Is that an elevation?

S: An elevation, um, hmm.

I: Okay. How do you do that?

S: You have to define the elevation view and which direction you're looking in and how deep you're looking.

I: How do you do that in the program? Do you key in some specs?

S: You'd click off the menu options on the screen that would place an elevation section cut bubble to define the direction of view. Then it would prompt you for the depth of your view in cone. In this case I'd generally enclose the whole office to get the depth of the office to project all the walls.

I: What would you do after you've projected the elevation in 3-D?

S: Make sure I'd like the office arrangement, furniture-wise.

I: What would you do if you didn't like the way the furniture was placed?

S: I'd move it around until I like it. Like the way you come in and out to the desk from the door.

I: So your criteria for appropriate office placement would be traffic flow and accessibility?

S: Um, hmm.

I: Anything else?

S: I'd have to spin it around and look at it in 3-D and shade it.

I: What does shading do to the drawing?

S: You're always looking at wire frame, so shading will add color to give you the feel for depth.

I: So, wire frame is the outline-type of programs that a lot of people are familiar with seeing . . . or CADD drawings that people are used to seeing that look like hand rendered drawing, but shading adds depth and feel to it . . . color?

S: Um, hmm.

I: Anything else?

S: Spin it around.

I: Look at it from different angles?

S: Um, hmm.

I: Why would you look at it from different angles?

S: Always like to do that . . . pretty interesting.

I: Okay. Thank you very much.

Subject 2
Problem 2
Interview 1
TRANSCRIPT

Problem: Design a 3D office layout within a 12 x 14 foot office.

I: When did you actually start to work on this problem?

S: One day last week.

I: And when did you finish?

S: Just a few hours after I started . . . two or three hours.

I: Okay. What's the first thing that you did?

S: I used this for notes . . . Do you want to know how I did it with the software, or . . .

I: Right from scratch . . . right from the start.

S: Okay. The first thing I did was, I laid out the basic walls . . . the outline of the office, using the twelve foot by fourteen foot inside diameter . . . inside measurements.

I: Did you do that on paper or on the computer program?

S: On the computer.

I: Why did you use inside dimensions?

S: Uh, so the measurements would come out better . . . easier for me.

I: And how did you lay it out on the software program itself?

S: We have a special architectural program that you build walls with, and doors . . . lays walls in and doors . . . gives you double-line walls automatically.

I: Is double-line the state-of-the-art in drafting . . . two lines for a wall?

S: That's pretty much state-of-the art, but this is also a 3-D design package, also. So it will give you a 2-D plan drawing, then when you get ready to take it into 3-D, it can be converted and it will convert everything into a 3-D picture for you.

I: Did you have a choice of software packages to use?

S: No.

I: So, the reason you used that particular 3-D package is that's what's available here?

S: That's what we had access to.

I: And so, the first thing you said you did was to lay out the basic walls, the twelve-by-fourteen using this architectural software. What did you do after you laid out the basic outline?

S: Okay. Then I put a three-foot door in, at the front of the office . . . about six inches off one wall. And, uh, that was so, when you push a door close to one wall you get a lot more wall space. You don't want to split a room with a door, because you've ruined that one wall.

I: Why did you use a three-foot door?

S: That's . . . basically, for office buildings and commercial stuff, that's code, because it has to be big enough for handicapped.

I: So you used a three-foot door because it meets code and because it is handicapped accessible. You put it six inches off one wall so that way you'd have more wall space.

S: Um, hmm.

I: What did you do after you put the door in the design?

S: Then I put in windows on the back wall that I would assume is the outside wall, across the whole back wall.

I: So you put windows in that went from one end of the wall to the other end?

S: Um, hmm.

I: Any particular size?

S: They're three-foot wide. I could have made them any height. I probably would set them off the floor two-and-a-half feet, maybe three.

I: Why would you use those dimensions: three feet wide and two to three feet off the floor?

S: I used four windows and it came out twelve foot on the

back.

I: That's why you used three-foot windows. And why would you set them two to three feet off the floor?

S: So you could, if you wanted to slide a desk under it you could. See, our windows here go almost all the way down to the floor. You can't really put a desk up against it because it really doesn't look good.

I: Okay. So the reason you put windows along the back wall is because you assumed that would be an outside wall?

S: Um, hmm.

I: What's the next thing that you did after you put the windows in the office.

S: Then I started populating the office with furniture -- I put quite a bit of furniture in it.

I: What furniture did you put in?

S: I put a three-foot by six-foot . . . executive desk -- has drawers on both sides. And then I put an executive high-back chair. And a fifteen inch by five foot credenza. And a two-drawer lateral file. And I put trash can in, and a telephone, and a . . . put a two-foot-six by five-foot desk. And on top of that I put a computer and a printer. And I also put a plant in it . . . had some plants, so I put a plant in it. And a guest chair in front of the desk.

I: Anything else in terms of furniture?

S: Hmm-um. That's about all I could get in.

I: I have a number of questions about the furniture. One is just a general question: why did you choose all this furniture in terms of what kind of assumptions you made about who was going to use the office?

S: What I did was just assumed it would be . . . I kind of fixed it up because I figured it would be a managerial-type person. And they would need a lot of storage space, a lot of file space. That's what the lateral file and the credenza are for.

I: The reason you put the fifteen inch by five foot credenza and the lateral file cabinet is for storage space?

S: Um, hmm.

I: Why did you use a three-foot by six-foot executive desk?

S: That's a nice size, good looking desk for a manager.

I: Okay. You mentioned specifically, too, that it has drawers on both sides. Is that a factor, also? Was that for storage?

S: Um, hmm -- for storage also.

I: Why the executive high-back chair?

S: Nice chair for the manager.

I: Trash can is pretty obvious. Phone . . . Why did you put a two-foot-six inch by five-foot desk with a computer and printer?

S: That's for the forward-going manager person. The one that knows how to use a computer and uses it and has a printer to do it with. Which is getting to be more and more popular and regular . . . You see that a whole lot more now.

I: What about the plant? Why did you place the plant?

S: That's basically for aesthetics.

I: And the guest chair?

S: That's for if you have a visitor. You want them to be able to sit down.

I: What about the arrangement of the furniture?

S: That had to be taken into consideration. You need to have . . . you need to have close to three-foot space for, in your traffic area.

I: Why do you need three-foot . . .

S: . . . for basically the same reason as the door. You need to have that much for handicap accessibility. And you don't want to be, even if you're not handicapped, you don't want to feel closed in and hitting your legs on your desks and stuff. It was a pretty good feat to make it all fit in there without being in each others way. But it worked out.

I: This is the second time you mentioned handicap accessibility. Why are you thinking in terms of handicap accessibility?

S: You just have to. If you don't . . . if you do any kind of commercial or industrial, or any type of construction, or design, it has to be there. Even in going to the bathrooms here, there are two regular stalls and a handicap stall . . . a wider stall with hand railings and everything. It just has to be considered. You have to have handicap runways for a wheelchair to be able to move in and out, no steps. It just has to be considered.

I: Okay. In going back to the furniture and the size of the room, did you think about what furniture should go in or the size of the room first?

S: I started laying out the furniture first to see . . . because I thought what the person might want. Then I threw it all, put it all in the room, and then I began arranging it to see if it would work out. And fortunately, it worked out pretty good.

I: Why did you think in terms of what the person needed before you thought of space?

S: I . . . if it was my position, I'd say, "Well, this is what I want. Can you fit it in there?" And then whatever . . . if it wouldn't fit, then I'd have an idea of what I'd have to start taking out.

I: So, it sounds like the way you thought through the project is, you made an assumption about the client, who the client is, then you thought in terms of what that client would want in the room. And then you manipulated the furniture to fit the constraints of the room.

S: Right. I did have a three-foot by five-foot desk for the computer, and the printer. And that was going to make . . . six inches is six inches . . . if you have a two-foot-six walk area, you need six inches. So that's why I cut it down to two-six. And that gave me an extra six inches, which made one walk area big enough. So I did have to make a desk smaller.

I: Is that the only piece of furniture you had to replace once you got it in the room, or were there others that you had to resize?

S: I had to move . . . I didn't have to replace any, but I did have to move some stuff. I had the credenza right next to the person. His desk is in this orientation, facing the door. The credenza was to his left, and the walk space coming out next to the credenza was too tight. So I moved the two-drawer lateral file from the wall the door was on to

the wall to his left, then move the credenza to that wall and it cleared it up.

I: You had the credenza to his left first and the file on the wall with the door originally. Why did you have that arrangement first rather than the other way around?

S: So the credenza would be accessible to him. I figured he'd want to be closer to it first. I've never had a credenza, so I wouldn't . . . I've never been that high up, but I assumed that he might want that closer to him . . . he or she, I must say . . .

I: Let me go through this again. You said it took you two or three hours from the time you started to solve the problem to the time you actually finished the design. First thing you did was to lay out the basic outline of the walls, and you used the twelve by fourteen measurements as inside dimensions. You used a particular kind of architectural software that you have in-house, and that's the reason you used it, because that's what's available.

S: We also think it's the best.

I: So you had done some evaluation some time ago before you guys even decided on that?

S: Yes.

I: The entrance door is a three-foot door six inches off of one wall, the reason it's a three-foot door is for handicap accessibility, and that's what code calls for for accessibility. The reason you have it six inches off of one wall rather than placed anywhere else on that wall is that way you'll have more wall space. You have windows going along the back of the wall -- the windows are three feet wide and you have four windows for a total of twelve feet. They're set two to three feet off the floor. The reason you have them two to three feet off the floor is so you can push a desk or other piece of furniture up against that wall. Why do you have windows in the first place?

S: I did a lot of house design before I came here, and the reason you had windows in every room is because there's fire code for that. It might be the same here, but the windows don't open, so I don't know if it would do any good or not. It might be fire code, but the reason I did it is for light inside the office. It's good to have regular sunlight during the day. You don't need to be dependent on fluorescent lights, or whatever you have in the office. It's nice to be able to see outside during the day occasionally.

I: After you designed the windows along the back wall, you populated the office with furniture. It sounds like once you get the door and windows designed into the office, structurally that's all you have to do -- put the walls up, the windows, and the door
-- for an office this size.

S: Um, hmm.

I: Then you populated the office with furniture. You told me the reason . . . the way you thought through that part of the project, you assumed that it was going to be for a manager. The next step you used to determine the furniture, was you thought what furniture that manager would use the most and want. Then you thought in terms of sizing the furniture and spacing it. In fact, you had to cut down on the size of one piece of furniture, the desk with the computer on it, from three-foot by foot to two-six by five. The reason you have an executive desk is it's a good size, it's nice looking, the reason you have an executive high-back chair is that it's a nice chair. The reason you have the credenza and the two-drawer lateral file is for storage. You assume the manager would want a lot of storage space for materials. You have a trash can. You have a phone. The computer and printer . . . you tell me managers more and more, at least in this business -- and I'm assuming it's for this business . . .

S: Um, hmm.

I: . . . are using computers and printers more and more. You put a plant in for aesthetics, a guest chair for visitors. We talked a little about why you needed a three-foot space for traffic areas, and it's for handicap accessibility and for compliance to code. What did you do after you finished populating the office with furniture?

S: After I did that, I used the software package to project the office into a 3D office . . . to make it three dimensions.

I: So you used the software package to project 3D. What did you do then?

S: That was it. I looked at it. I shaded it and looked at it.

Subject 2
Problem 2
Interview 2
TRANSCRIPT

I: What would the first thing that you'd do be?

S: The first thing I'd do is just lay out the walls using the dimensions as inside dimensions.

I: Why would you lay out the walls first?

S: That's the first thing you do to know what you're going to do on the inside.

I: What would you do to lay out the walls . . . in terms of the software program that you're using?

S: The software we use lays out the walls automatically. All you've got to do . . . if you have four walls, you pick this command that's called "place room: . . . or whatever . . . and it places one whole . . . four walls. You give it the first digitizing point and key in the dimensions and it'll lay it in for you.

I: Okay. The first thing you do is lay out the walls using a software program. You do that by putting a point on the screen with the digitizer, and then the computer program will automatically lay out the walls according to the dimensions you lay into it?

S: Double-line walls.

I: Okay. What would you do next?

S: Put in a door.

I: Why would you put in the door as the second step?

S: It's not anything in particular, step-wise; it's just preference-wise.

I: Anything special about the placement of the door, the size of the door?

S: Yeah . . . try to put it close to one wall . . . so you can have more wall space to lay out furniture.

I: How about the size of the door?

S: Three foot.

I: Why would you use a three foot door?

S: 'cause that's the minimum size on an office door for code . . . handicap accessibility.

I: So, you'd lay in the walls, and you'd put in the door . . . what would you do after that?

S: Go ahead and lay out the windows. Assuming that the back wall is an outside wall.

I: So you'd assume that the back wall is an outside or exterior wall. Any particular reason why this step is coming when it's coming?

S: Nah.

I: Preference?

S: Um, hmm.

I: What would be . . . how would you lay out the windows?

S: I would have made the back wall, probably the twelve foot dimension. Have three . . . or four, rather, three foot windows . . . modular purposes.

I: Okay. And how do you do that? How do you lay out the windows using the software program?

S: It has a "window" command. You'd actually go in and put the data point where you want your window and your size . . . actually, it's database driven, and it has all the sizes. And you can either select the default size that it has at the current time or you can go into the database and select a different size window and it will put it in for you.

I: Okay. What would you do after you've laid-in the windows?

S: Then you start laying out furniture.

I: How do you do that?

S: The way I did it was . . . actually, it probably was . . . it's not necessarily the wrong way to do it, but it's the way we've been laying out offices over at ours. Everybody decides what they want, and then we try to see if it works, and then if does, fine. And if it doesn't, start taking furniture out. So I just threw in a bunch of furniture I assumed that the person would want, then start

trying to arrange it to where you could get around in the office.

I: So, the type of furniture came first before the sizing, and that type of thing.

S: Um, hmm.

I: How did you decide what type of furniture? What assumptions did you make about the office and what kind of furniture to lay out?

S: I just . . . just for . . . no particular reason. I just decided . . . thought it might be a manager's office.

I: So, an assumption you're making is that it's the manager's . . . a manager's office. How do you lay out furniture . . . using the software program?

S: It has a . . . actually there's another . . . software program we have other than "Project Architect," which is called "Project Layout." And it does inside office design -- furniture, and . . . steel case partitions, and all different kinds of furniture . . . chairs and desks and partitions . . . even small things, such as phones . . . like that.

I: Does "Office Layout" (sic) an "Intergraph" add-on, or is it stand-alone?

S: It's an "Intergraph" package.

I: Okay. What furniture did you choose for the office?

S: Chose a three foot by six foot, two-drawer desk . . . right, left . . . actually, I guess it would be a four-drawer desk, 'cause it had drawers on each side.

I: Okay. Why did you choose that type of desk?

S: Just for the extra room . . . extra storage.

I: Okay. And, what else . . . in terms of furniture? What other pieces?

S: Credenza.

I: Okay. Why did you choose a credenza?

S: That's for looks and storage.

I: What else?

S: I'd have a two-drawer lateral file . . . for files.

I: Why did you choose two-drawer lateral file as opposed to any other type of file?

S: They're . . . well the two-drawer, if you buy furniture that's close to the same brand and looks the same, it could almost be modular. You can move it up next to your desk and it would be about the same height and it will look good if you have a space problem. You could slide it up next to your desk and put stuff on it, then you'd have your lateral files to put you folders and stuff in.

I: Okay. What other furniture? Anything else?

S: I'd have a table -- a five foot by two-and-a-half foot table to put a computer and printer on.

I: Okay. Why did you have that table?

S: Because, hopefully, now-a-days the way things are going, everyone just about has a computer sitting on their desk . . . even the upper management are starting to use them a lot more. So, it would be nice to have an area to put one. Plenty of room, because, you get a good size computer and a printer, you've taken up four foot, five foot area.

I: What else? Anything else?

S: I think I've just put a telephone it for the look . . . the three dimensional look. And an executive chair.

I: What do you mean you'd put a phone in for the looks?

S: Well, you know, just something to add to the three dimensional look whenever you bring it up into three-D.

I: Okay. Is that something that would be used by a manager, though? Is that why there's a phone in the first place?

S: Oh, yes! Definitely.

I: And the executive chair -- what . . . why did you put an executive chair?

S: Just a nice chair for . . . high back chair for that person.

I: What did you do after you placed the furniture?

S: Just added a few other things for . . . actually, put a guest chair in, because you need one. Like, right now, I'm

sitting in your guest chair. And a plant for looks, aesthetics.

I: Okay . . . plant for aesthetics . . .

S: After you've laid-in all the furniture, then you can project-up the walls, doors, and windows into three-D . . . the completed three-D look.

I: Okay. Let me summarize where we've gone so far. In doing this problem the first thing you'd do is lay-out the walls using the inside dimensions. Put in the door, and the door would be close to one wall so you'd have more continuous wall space. It would be a three foot wide door because of handicap accessibility required by the code. You're assuming that there's an outside that you place windows in. That one of the walls . . . that the wall that you'd place the windows in is one of the twelve-foot walls so you could put three, four foot windows. You laid out the furniture, and you determined the furniture based on what you thought would be needed prior to figuring out sizing of the office. You're assuming it would be a manager's office, so you put a three foot by six foot two-drawer desk, which actually has four drawers -- two on each side. You want a desk like that because it offers a lot of storage capacity. You put in a credenza for looks and storage. You have a two-drawer lateral file that you can butt-up against the desk and it would fit in a modular way with other furniture. You'd have a five by two-and-a-half foot table for a computer and printer. You're assuming that the manager would have need for a printer. You'd add a phone for obvious communication reasons. An executive chair. You'd have a guest chair so that when you have a meeting, the guest would have a place to sit. You'd have a plant for aesthetics. After you put the furniture in the room, then you'd project the drawing into three-D view. Why would you do that?

S: Just to go and you can see what's going on in your drawing more if your manager wants to come up and look what his office is going to look like. If you're looking down on a two-D plan, you can kind of see what's going on. But you shoot that thing up in three-D and maybe even shade it for 'em, and get down inside the office and move 'em around in there, they can really see what it's going to look like.

I: What is shading?

S: That's when you take a "wire frame" and paint it. It paints all the different desks and everything . . . like you saw <referring to other drawings the interviewer looked at before the interview began>. All those were shaded views,

actually. Shaded with patterns. You can do just a color shade or you can do a shade with patterns . . . to show like wood grain on a desk, and stuff like that.

I: Okay. So, then, after you look at the drawing in three-D view, what's the next step?

S: That's it. Unless you want to go to video with it.

I: Thank you very much.

APPENDIX D: ANALYZED TRANSCRIPTS

APPENDIX D: ANALYZED TRANSCRIPTS

This appendix contains transcripts that have been analyzed using the Action-Reason Thematic Technique.

Subject 1
Problem 1
Interview 1
ANALYSIS

Problem: Set up the seed file(s) for a project with a maximum of five drawings (one each of the following: mechanical, electrical, civil/structural, architectural, cover sheet).

I: Michael, when did you first start to solve the problem?

S: On the 7th.

I: April 7. Okay. When did you finish solving the problem?

S: On the 7th.

I: So you solved the problem all in one day.

S: Yeah . . . in give or take an hour.

I: What's the first thing that you did in solving the problem?

S: [I wrote down ideas as I went along. **(1)**There are similarities of various drawing styles . . . **(2)**I grouped them together accordingly.]

1. "There are similarities of various drawing styles."

2. "[If 1] I group them together accordingly."



I: Why did you do that?

S: [Several reasons . . . **(3)**the mechanical and electrical are so similar that they can be drawn at, what I'm going to

call, a scale of one-to-one . . . (4)where the border is going to have to be increased proportionately with the scale of the drawing. Everything can be done just by slapping in little parts of the drawing, just put 'em all in -- not have to worry about scaling 'em up, and fit together. (5)Civil, structural, and architectural -- a lot of them have various scale details . . . (6)so therefore the borders might have to be scaled up to match the proportion of the drawing. So I kind of narrowed it down to needing only, absolutely needing, only two seed files.]

3. "Mechanical and electrical drawings are done at a scale of one-to-one."

4. "[If 3] The borders are increased proportionately and there is no need to rescale drawings to fit together."



5. "Civil, structural, and architectural drawings have various scale details."

6. "[If 5] The proportion of the borders might have to be scaled-up to match the proportion of the drawing."



I: What is a seed file?

S: When you go into Intergraph to create a new drawing, that is the file that the program reads to create a new drawing . . . the way I look at it is like planting a seed to a plant. Once you plant a seed, from that point on, everything grows from that seed . . . all your drawings . . . so all your new drawings originated from the seed file . . . in essence your copying the seed file with parameters already set up in that file, where you don't have to go set 'em every time you make a new drawing.

I: Okay. So every time you start a new drawing you start a seed file?

S: Um . . . hmm.

I: And that's the basis for all of your drawings for any particular project?

S: Right.

I: So the first thing you did in this particular project was to determine the similarity of drawings and group them. You say the electrical and mechanical you group together because, pretty much, they use the same scale?

S: Right.

I: And then civil/structural and architectural are similar . . . they also have the same type of scale and you can use the same seed file for both of those types.

S: [Correct. **(7)**And given that there were only five drawings at the end of the project, **(8)**only one seed file was absolutely necessary.

7. "There were only five drawings"

8. "[If 7] then only one seed file is necessary."



I: So you set up one seed file for all five types of drawings?

S: [Um, hmm. **(9)**I attached a border to the seed file, **(10)**therefore when you create your drawing, your drawing border comes in automatically, you don't have to go search for it and attach it, it comes in right with the drawing.

I: Why do you attach a border?

S: It pretty much saves time. When you create a drawing using that correct seed file, the border's already there.]

9. "I attached a border to the seed file."

10. "[If 9] the drawing border is drawn automatically with the drawing."



I: What is the purpose of the border?

S: [You have to have a border on 90% of your drawings. Like TVA, for example, they've got their own border they've asked us to use. **(11.)**So when we do a TVA drawing, **(12.)**we use a TVA seed file with a TVA border already attached to it.]

11. "The drawing is for a particular client organization."

12. "[If x] I use the client organization's border."



I: What does the border have on it?

S: Titling, project names, numbers, dates, engineers' names.

I: So the first thing you did was determine similarities of drawings and you combined mechanical and electrical because they're the same scale, and you combined civil/structural and architectural for pretty much the same reason. But you told me you only need one seed file for all of those . . .

S: The reason being, there's not enough drawings to concern myself with multiple seed files.

I: So you used one seed file for all of them. Why did you group them since you're only using one seed file for all of them?

S: [On a larger project I would most definitely group them together . . . **(13)**and the civil/structural-architectural . . . when you have a drawing of a scale of 1/2" to a foot, **(14)**you have to scale the border up twelve times within that seed file, so therefore, that's what I mean that mechanical-

electrical is one-to-one, meaning the border scale is one-to-one and you don't have to scale it. If there's a bunch of details like civil/structural-architectural, you'll need to scale up the border to twelve times.]

13. "Civil/structural-architectural drawings are rendered at a scale of 1/2" to a foot."

14. "[If 11] the border is scaled at twelve-to-one."



I: Are your drawings bigger for civil/structural than they are for mechanical and electrical?

S: Right.

I: But on this particular problem, you only did one seed file for all of them because there were only a small number of drawings?

S: Right.

I: So you didn't actually have to group them for this particular problem.

S: Once I realized the number of drawings, it turned out to be a wasted step.

I: Did you do that step in this particular project before you determined it was wasteful?

S: Um, hmm.

I: So the first thing you did was determine the similarities and group them. Then you attached a border. Then you scrapped the idea of grouping because there weren't that many drawings. What was the next thing that you did after you scrapped the idea of grouping?

S: I went into the seed file and set up all the parameters that I personally like to use and recommend.

I: What were some of those parameters?

S: Text sizing, grid spacing, default level, line weights and codes, and dimensioning attributes.

I: So you draw on a grid.

S: Um, hmm.

I: What did you say after grid spacing?

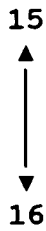
S: Default level.

I: What is "default level?"

S: [When you go into a drawing, you're generally on level one, **(15)**but since a lot of the text you place in a drawing is on level 46, for general note-taking and so forth, **(16)**I made that default.]

15. "The drawings require a lot of note-taking."

16. "[If 15] the default level is set to 46."



I: And after setting default level, what did you do next?

S: Set line weights and codes and dimensioning attributes.

I: What are "dimensioning attributes?"

S: That's style of dimensions to be placed -- what types of arrowheads to be used.

I: Anything else after dimensioning attributes?

S: Then I attached the border.

I: A little bit earlier, I had that you determine similarities of drawings and group them, then you attach the border. But you didn't actually attach the border until after you set the parameters. So this step actually came down here someplace?

S: Right.

I: Attach the border . . . let me go back to text sizing.

I: How did you determine what size text to use?

S: [Standard is an eighth of an inch. Go back to the separations and similarities . . . you've got mechanical, electrical and cover sheet -- **(17)**when you have a drawing at a one-to-one scale, **(18)**your text sizing is going to be an eighth of an inch. So you've got three out of the five drawings are going to be an eighth of an inch.]

17. "Mechanical, electrical, and cover sheet drawings are rendered at a scale of one-to-one."

18. "[If 13] the text sizing is set at one-eighth of an inch."



I: In this case, you knew that three of the five drawings were going to be one-to-one scale, then you determined that one-eighth of an inch was going to be the appropriate scale.

S: Right.

I: Then grid spacing -- how did you determine that?

S: [**(19)**That's usually half of the text size.]

I: So if the text size is one-eighth of an inch, the grid size is one-sixteenth of an inch?

S: Uh, huh.

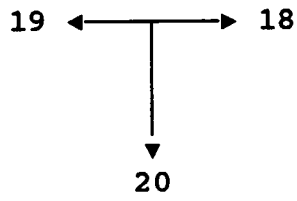
I: So, is that what you used in this case?

S: Yes -- that's pretty common, typical.

19. "The grid size used is one-half text size."

18. "The text size is one-eighth of an inch."

20. "[If 19 + 18] the grid size is one-sixteenth of an inch."



I: The default level you mentioned is usually level one, but because there is a lot of text in this one, you set a default of 46.

S: Right.

I: Is that pretty standard?

S: Uh huh.

[I: How did you determine line weights and codes?

S: **(22)**One is the standard for text, and line code zero is standard for text and any new lines you have to draw . . . straight line.

I: **(21)**So for this particular problem you decided to use standard line weights and codes?

S: Um hmm.

I: And why did you decide they were appropriate?

S: In 99% of the cases its what would be standard.

I: Is that the rule-of-thumb that you used?

S: Yeah.]

21. "I used standard line weights and codes."

22. "[If 21] I used line code one for text and line code zero for new lines."



I: [The dimensioning attributes that would include such things as arrowheads -- how did you determine those attributes?

S: I set 'em to what I usually like.

I: Is it a personal preference kind of thing?

S: Pretty much -- drafting standards still have a lot to do with it, but **(24)**I set 'em to what I like since **(23)**I didn't have any guidelines.]

23. "No guidelines were given for dimensioning attributes."

24. "[If 23] I set dimensioning attributes to what I like."



I: Talk to me about the arrowheads -- is there a certain name for the arrowheads? Or, how would you describe the arrowheads?

S: A filled-in arrowhead.

I: What about the sizes of the arrowheads or the shape -- anything special about that?

S: It's . . . the length of it is equal to the height . . . text height.

I: So the length, in this case, was one eighth inch?

S: Um hmm.

I: And when you do a drawing, do you typically use that as a rule-of-thumb?

S: Yeah, you don't have any control over the length of the terminator arrowhead. It reads the text height and sets it for you according to the text height, so you don't have much control.

I: Okay . . . what other attributes did you have some control over?

S: Default cell library that is attached to the drawing.

I: The "default cell library?" What is the default cell library?

S: [Cell libraries consist of parts of the drawing, like a section bubble or something pretty typical that you build in one area. Then you can attach that file to your drawing and place all the parts in the file. So I determined the general cell library would contain all the common . . . the most common, needed details like the heading bubbles, section cut bubbles, and that kind of thing.

I: For this particular problem, why did you determine they would be the standard ones that you'd use?

S: Well, because you'll place the titles and that on the drawing, and that's where this library comes in handy -- it's got all the title headers and details.]

25. "I determined that I would need title headers and details."

26. "[If 25] I use the general cell library."



I: So for this particular drawing you decided that this was the appropriate thing to do.

S: Um hmm.

I: Just to summarize -- you determined the similarities of the drawings and you grouped them electrical-mechanical and cover sheet and decided that one-to-one scale was appropriate. You grouped civil/structural and architectural and decided that they seemed to fit together. Then you scrapped the idea of grouping due to the small number of drawings for this particular problem. Then you set the parameters of the seed file, including text sizing -- and you determined that text sizing should be one eighth of an inch because that's pretty standard for one-to-one scale drawings.

S: Um hmm.

I: Then you determined the grid spacing, and that's one-half the text size. So for this particular drawing -- or set of drawings -- your grid spacing is one-sixteenth inch. Then you set the default level and, while most of the time you

set it at "one," this time you set it at 46 because of the amount of text in this set of drawings.

S: Um hmm.

I: Then you set the line weights and codes. You set your line weight to "one" and your code to zero because that's standard operating procedure and you decided that would be appropriate for this set of drawings.

S: Right.

I: You set your dimensioning attributes. There are standard drafting practices to determine your styles and dimensioning attributes, but the bottom line is that in that range of acceptable practices you determined the ones you liked.

S: Um hmm.

I: Then you attached your border. You mentioned TVA. Is this set of drawings for TVA or someone else?

S: No, I think this was for the "Corps."

I: The Army Corps of Engineers?

S: Um hmm.

I: So did you use their standard border?

S: Yes.

I: So the way you determined which border to use was to use their standard border?

S: Right.

I: What did you do after you set your parameters of your seed file?

S: [**(27)**I saved the settings of the seed file.

I: Why did you do that?

S: **(28)**Otherwise, it won't keep some of these attribute definitions.

I: After you set the attribute settings, you save the seed file.

S: From that point on, you don't have to save them again.]

27. "I save the settings of the seed file."

28. "[If 27] the file maintains the attribute definitions."



[I: What did you do to save the settings? What is the actual procedure?

S: Control-Z . . . no, **(30)**control-F.

I: Why did you use control-F? Is that the standard?

S: **(29)**Yes, and it's faster than typing in "file."

I: You could save it by typing in file?

S: Yes, or you can use the icon on the screen, but you have to search for it.

I: So control-F for you is easier than searching for the icon and clicking with a mouse?]

29. "Typing 'Control-F' is faster than typing 'file' or using the mouse to save the settings."

30. "(If 29) I type 'Control-F' to save the settings."



S: Right.

I: After you save the settings, what was the last thing you did?

S: That was pretty much it.

I: So that's the whole process of setting the seed file.

S: Um hmm.

I: You started the process on April 7 and finished that same day. It took you about an hour to solve the problem. The first thing you did was to determine the similarities of drawings and group them electrical-mechanical and cover sheet, because they're all one-to-one scale. Then you grouped civil/structural and architectural -- and they're the same scale. Then you scrapped the idea of grouping because of the small number of drawings involved for this particular problem. Then you set the parameters of your seed file. Now, did you decide to use a one-to-one scale for all the drawings?

S: Right.

I: Regardless of the fact that civil/structural and architectural are smaller scale?

S: Larger scale. There is a need to scale up the border, so everything set in proportion, and when you scale things up in proportion you can easily determine what size to set your . . . like your text height, and everything again. Given the fact that there are only five drawings and three of the five will be eighth of an inch text sizing, I figured that's the easiest way to go.

I: So you went one-to-one because the majority of the drawings were one-to-one anyhow?

S: Um hmm.

I: But if the majority of the drawings were some other scale, that's what you would have used to . . . go to that scale instead of one-to-one.

S: Right.

I: So you scrapped the idea of grouping due to the small number and used a one-to-one scale because three of the five drawings used that scale anyway. Then you set the parameters of the seed file. You set the text sizing, which was one-eighth of an inch when it's one-to-one scale; you set the grid sizing, and your rule-of-thumb for that is one-half text sizing to determine grid sizing; you set the default level, and you set it to 46 because of the amount of text in these drawings . . . typically you'd set it to one.

S: Um hmm.

I: You determined the line weights and codes and thought the typical line weights and codes would be appropriate for these drawings.

S: Right.

I: You set the dimensioning attributes, and within a range of acceptable drafting practices you used your own good taste or desires in picking your dimensioning attributes. Then you attached a border. And the border you attached was the Army Corps of Engineers' border, because that's who the client is.

S: Um hmm.

I: Then the final step was to save all settings, and you saved all settings by typing control . . . pressing the control key and the "F" key simultaneously. And the reason you did that was, even though there are two other ways of saving the settings, you liked it best because it is faster than typing the word "file" or clicking on the file icon.

S: Right.

I: Okay. Thanks a lot.

Subject 1
Problem 1
Interview 2
ANALYSIS

Problem: Set up the seed file(s) for a project with a maximum of five drawings: one mechanical, one electrical, one civil/structural, one architectural, and one cover sheet.

I: This is the second interview on the problem, and you've gone through both the expert system program and the hypertext program. What is the first thing you'd do in setting up the seed file?

S: [**(1)**I'd have to determine the organization, the job organization you're working for, to attach the border, attaching the border for that seed file.

I: So you'd determine the client organization that you're working for?

S: The client. Whether their border needs to be attached to the seed file.]

1. "I determine the client organization."

2. "[If 1] I can determine appropriate border for attaching."



I: What would you do after you've determined whether you have to attach a client border to the seed file?

S: [**(3)**I would take in mind how big the job is . . . **(4)**to get an idea of how many seed files I'd actually have to create for each various scale factor involved in the project.]

3. "I determine the size of the job."

4. "[If 3] I can determine how many seed files I'd have to create for each of the various scale factors involved in the project."



I: Scale factor? What do you mean by that?

S: Might have a floor plan that requires a quarter-inch-to-a-foot drawing. And you might have some detail layouts that require half-inch-to-a-foot drawing. [(5)Each of those scale factors (6)would mean a different seed file for each, so the border would be set to match the scale factor.

5. "I determine there are different scale factors."

6. "[If 5] I set the border to be set to match each scale factor."



I: For each scale factor . . . if you have different scale factors, you'll need different seed files?

S: Right.

I: [So you determine who the client organization is and whether you need to attach their border to the seed file. (7)Then you determine the number of seed files per scale factor. What would the next thing be that you'd do?

S: (8)I would start with the first seed file and set all my parameters up accordingly, such as dimension attributes, text levels, and client standards.]

7. "I determine the number of seed files per scale factor."

8. "[If 7] I set all parameters up accordingly."



I: [How would set the dimension attributes?

S: **(9)**I'd have to read through the client's procedures first **(10)**to determine their requirements and follow them.]

9. "I read the client's procedures."

10. "[If 9] I determine the client requirements and follow them."



I: [Where do you read through the client's requirements? Is that in the contract?

S: **(11)**Sometimes we are lucky enough to get a copy of their standards. **(12)**If not, **(13)**we'll go by our own standards which define line weights for dimensions and various title headers . . .]

11. "I have a copy of the client standards."

10. "[If 11] I will use them to develop dimension attributes."



12. "I don't have client standards."

13. "[If 12] I use my company's standards to develop dimension attributes."



I: So, if client standards are available you use theirs, if they're not, you use yours.

S: Right.

I: After you determine dimension attributes, you said something about text. What are some of the attributes there?

S: Text sizing. Spacing, links, and even level . . . colors.

I: [**(14)**What are some of the things you do in setting text sizing, levels, and colors?

S: **(15)**It's just a little short key-in, like "t.x. equals text height." Real short, brief, command key-ins.

14. "I want to set text attributes."

15. "[If 15] then I key in the appropriate short commands."



I: [**(16)**And how do you determine what text size to use?

S: **(17)**Go by the scale factor involved with the drawing.]

16. "I want to determine text size."

17. "[If 16] I go by the scale factor of the drawing."

16



17

I: So, if the scale factor is one scale, then the text is another . . . what would an example be?

S: An example would be a quarter-inch-to-a-one-foot drawing would require your text height to be set at six inches.

I: And you said something about levels. Were you talking about text levels or something else?

S: Yeah -- text levels. Set that as a default where your text is set at that level.

I: What are you doing when you're setting text levels?

S: It's another quick key-in.

I: What does that do, though, in terms of a drawing?

S: It will activate that level number to be the default or the active level.

I: Are there any other parameters you need to set . . . text levels, color, that kind of thing?

S: [**(18)**If it were to be a three-dimensional drawing, **(19)**I'd set the view attributes.]

18. "The drawing is to be three dimensional."

19. "[If 18] I set view attributes."

18



19

I: So if it's a three-D drawing, set the view attributes. And what are view attributes?

S: Well, we can have the one view looking at the top plane, another view set to look at the front, another view set to the right, another view, the iso view, to get a full three-dimensional effect.

I: [**(20)**How do you set view attributes?

S: **(21)**Turn some more views on. You only have one view turned on when you go into a drawing, so you have to turn some views on, using the mouse to pull up a hierarchical menu to activate more views and, then you would define the views, using another dialogue box.]

20. "I want to set view attributes."

21. "[If 20] I turn multiple views feature on."



I: [**(22)**What do you do to define views?

S: **(23)**In the dialogue box, you can activate the view number and define a parameter to it, such as front, top, back, or isometric.]

22. "I want to define views."

23. "[If 22] I activate the view number and assign a defined parameter to it."



I: You determine who the client organization is and whether you have to attach their border to the seed file, you determine the number of seed files per scale factor, then you set your parameters. The dimensioning attributes are determined either by client requirements, if available, or your own requirements. You set up your text levels, your

text size, your text spacing, etc. If it's a three-D drawing, you set view attributes, turning views on and defining views. What do you do after you set the parameters?

S: Well, about all you have to do from that point is save them. So they'll be active.

I: Save all the parameters?

S: Save all the parameters.

I: [**(24)**How do you save the parameters?

S: **(25)**File -- either Control-F, which I normally do, or type in "file," or pull it off the dialogue box.]

24. "I want to save parameters."

25. "[If 25] I type Control-F or "file," or I pull it off the dialogue box."



I: What do you mean by "pull it off the dialogue box?"

S: Works like Windows. You've got the file choices, you pull it down and save.

I: Using your digitizer?

S: On my machine I have a mouse.

I: Let me go through this one more time to summarize. You determine who the client organization is. You determine whether you have to attache their border to the seed file. You determine the number of seed files per scale factor. You set parameters which include dimensioning attributes, using the client's requirements if you have them, using Stone and Webster's if you don't. You set the text attributes . . . text parameters, such as the size of the text, spacing, color, that type of thing. If you're doing a three-D drawing, you set the view attributes by turning the views on, defining the views, etc. You save the parameters

by using Control-F, which is what you usually do, typing in the file . . . is that the file name?

S: Typing in the word "file."

I: . . . or pulling of the dialogue box. Going back to the three-D drawings . . . how do you determine if you are going to do a three-D or two-D drawing?

S: For example, if you're going to do an architectural floor plan, what we use is project architect. It's pretty well all three-D. So anything . . . you have to use three-D with them.

I: All architectural drawings are three-D?

S: Right.

I: So, if it's architectural, then it's three-D.

S: Even mechanical . . . if we're using any duct work within a building, it has to be a three-D drawing. Eighty percent of our work now is three-D, so any we set up are three-dimensional.

I: Let me go back to determining the number of seed files per scale factor. I think we touched on this, but how do you determine the number of seed files per scale factor?

S: You only need one seed file per scale factor, it's a matter of how many various scale factors you need.

I: How do you know how many scale factors you need?

S: Well, pretty common . . . we stay within a range of quarter-inch, half-inch, and three-quarter inch. Sometimes a little different. So usually three to four will get us any scale factor we need.

I: So any drawing or set of drawings might require more than one scale factor?

S: Right.

I: And how do you know which one to use and when?

S: Luck of the draw, sometimes. Depends on how much of the drawing you need to fit, and if it doesn't fit, just create it in a different scale factor -- it's pretty quick and easy.

I: So you're constrained by the size of the output . . . the paper?

S: The floor plan, so to speak. If you have a big 100 foot building, you draw . . . the project architect will draw 100 foot long, so you may need a quarter-inch border, which is scaled up bigger than a half-inch to fit the building in the drawing itself.

I: So, typically the larger the object you're drawing . . .

S: . . . the smaller the scale.

I: So you determine the organization. The need to attach the border to attach the border to the seed file. You determine the number of seed files per scale factor, and often, [**(26)**the scale is determined by **(27)**the size of the object you are drawing.] Sometimes, in a set of drawings, you might have different scales because of different size objects?

26. "I want to determine the scale of the drawing."

27. "[If 27] I determine the size of the object to be drawn."



S: Um, hmm.

I: You set your parameters, which include dimensioning attributes, which are typically determined by requirements, if available, and by Stone and Webster's if they are not. The text, which includes size, spacing, color, the levels . . . you determine whether you are going to do a two-D or three-D drawing, and typically, if it is going to be architectural or mechanical drawing, its three-D. Otherwise its two-D?

S: Yeah.

I: Okay. You set the view attributes by turning the views on and defining the view attributes in your three-D drawings. Then you save the parameters, which can be done

by typing Control-F, which is what you usually do, typing in the word "file," or pulling it off a dialogue box.

S: Right.

I: Anything else that we've missed?

S: Not that I know of.

I: Okay, great. Thanks.

Subject 2
Problem 1
Interview 1
ANALYSIS

Problem: "Set up the seed file(s) for a with a maximum of five drawings, one each of the following: mechanical, electrical, civil/structural, architectural, and cover sheet."

I: When did you first start to solve this problem?

S: The first or second day after we met and I received the packet.

I: And how long did it you . . . when did you finish solving the problem?

S: Well . . . between all the times I had a chance to work on it . . . a day, maybe.

I: So, it actually took you a day to work through the problem?

S: Yeah.

I: Okay. What's the first thing that you did?

S: Well, I took the problem, thought about it, and considered . . . [**(1)**the first thing I considered was the number of drawings that I had. There were just five drawings . . . and kind of based it on how, if you've worked at a certain place as long as I have, you kind of do it the way you've been doing it. So I figured to do it kind of like we do it now. And, if we were to get a job with just five drawings, we would set it up, or I would try to set it up as simple and quick as possible. If it were a 300-drawing package, and we get some projects like that, we'd have multiple seed files . . . cause it is worth the time to go into it. **(2)**Five drawings . . . make a good, straight cut seed file. It would be pretty generic.

I: So for this one, you made only one seed file?

S: Yes.

I: Okay. So the first thing you did was consider the number of drawings. Then you determined you could make one seed file because there were only five drawings?]

1. "The project requires a five drawings."

2. "[If 1] I use only one seed file."



S: Um, hmm.

I: What's the next thing that you did?

S: Started setting it up with the different parameters . . . that we do.

I: What's the first thing you did to set up the parameters?

S: Well, the first thing we did was set up locks. Usually the only lock we set is a "snap lock."

I: What is a lock?

S: [(3)Like you if you turn a grid on in a drawing, you can turn your grid lock on and it will snap to points in the grid. (4)You can draw lines to grid points . . . without having to do anything special. And if you've got a snap lock on, you can snap to the ends of lines . . . it will go straight to the ends. You don't have to do any calculations or anything else; it will just automatically shoot to the ends of lines.]

3. "You turn the grid lock on."

4. "[If 3] You can draw lines to the grid points."



I: So the first thing you did was to set up a lock. And, again, why did you do that?

S: The snap lock, or the basic locks we use, are . . . for ease of drawing. Basically, all of this . . . everything a seed file consists of is to make your easier, initially, to draw. And, uh, you can also set up . . . which also has to

do with your locks . . . a key snap, which gives a number of points it will snap to a line. If you have one line, you can divide that line up into a hundred points if you want to. So you can set a snap to any number you want to, and we always set it to "two." So it will snap to the middle of the line if you want to snap to the middle.

I: [(5)Okay. Why did you set it to snap to two rather than any other number?

S: (6)That's pretty basic . . . the mid-point of the line is what we use a lot of times.

5. "I want the line to snap to the mid-point."

6. "[If 5] I set the snap feature to two."



I: Okay, but what is the logic there . . . why is it good to set it to two rather than any other number?

S: There really isn't any . . . it is just . . . all the experience we have . . . if you want to move objects, and you want to center them, on another object, you just snap to the edge of a box, it will snap to the center of the edge of a box, and if you have a box that's bigger, that you want to center it on that box, you snap to the center of that one, and it will center it automatically. And you can set it up a hundred times and you can draw a hundred lines evenly spaced on one line.]

I: You mentioned "we set it up," is that standard operating procedure for Stone and Webster?

S: Yes. It's usually . . . it's what we, in this office, like to do. [(7)A lot of this stuff, the way I set it up is the way we like to do things which comes from experience -- (8)what works faster and actually . . . this office is probably setting most of the precedents in this company in Intergraph. Because we do most of the work in Intergraph, except, maybe, one or two offices in the entire company. So, we don't follow anybody's rules. Since we've started, we more or less make up our own.]

7. "I set the features up the way we like to have them in our office."

8. "[If 7] we set the precedents in our company for using Intergraph software."



I: So you guys are setting the standards?

S: Um, hmm.

I: [**(9)**You mentioned that, in setting up the parameters, one of the first things you do is set up the locks. Why is that one of the first things that you do?

S: Because that's . . . there really doesn't have to be any specific order. It's just one of the first things I come to. **(10)**You just want to make sure you take care of everything.

I: So for you . . . in this particular case, did you follow a set order for setting up your parameters?

S: Not really . . . it's just . . . most of it's in my head.

I: So you might set up your parameters in a different order for every set of drawings that you do?

S: Uh . . . you could.

I: But how about you . . . do you usually use the same kind of order every time you do a set?

S: Usually, yeah.

I: And why do you use the same order?

S: It's just from repetition. It doesn't matter what order you do things in a seed file, as long as you get them all.]

9. "One of the first things I do is set up the locks."

10. "[If 9] I set them up just to make sure I'm taking care of each step."



I: What did you do in this set of drawings? What did you do after setting up the locks?

S: I usually set the grid.

I: Is that what you did in this one -- set the grid?

S: Yeah. [(12)I set a certain grid spacing.

I: And what is "setting the grid spacing?"

S: Well, you set . . . I was telling you you have points . . . you set up those points . . . you usually set them to an eighth-of-an- inch.

I: Is that what you set them for in this case?

S: Yeah.

I: Why did you set them to an eighth-of-an-inch?

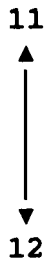
S: Because that's . . . it's not too much and it's not too little. You don't want to get down to a thirty-second or a sixty-fourth . . . usually, what we do, you don't even go to an eighth -- it's usually a quarter.

I: How do you determine to go to an eighth or a quarter?

S: (11)From experience. When we get drawings . . . especially architectural drawings, we rarely get anything incremented any further than an eighth . . . you may get a sixteenth, but if a carpenter was to look at a sixteenth-of-an-inch, they'd probably just laugh at it.]

11. "We rarely work on drawings that require smaller increments than an eighth-on-an-inch."

12. "[If 11] I set the grid spacing at an eighth-of-an inch."



I: So, for a lot of your work, especially if it's architectural, you don't go lower than an eighth-of-an-inch on your grid, and that's the case you used in this one?

S: Um, hmm.

I: So, what does . . . does that have to do with the scale of drawing?

S: No.

I: [(14)Is your scale one-to-one . . . is that how you set up this seed file?

S: Yes. You do your drawing "real-world," if you draw . . . if it says it's an inch long, (13)you draw it an inch long. And then you can set your scale up according to the border. You make your border however big it needs to be to give you your scale.]

13. "I set up the scale according to the border."

14. "[If 13] I set up a one-to-one scale in the seed file."



I: So the first thing you did was consider the number of drawings, and when you determined there weren't a great number, you decided to make one seed file for this problem because of the small number. Then you set up your parameters, and the first parameter you set up was the lock, or locks, then you set the grid. What was the next thing that you did?

S: You have what is called "view attributes."

I: What are they?

S: Those are how your screen displays objects. Like you can turn on . . . you have curves . . . you have what is called a "fast-curve display" . . . if it's on "slow-curve display" it will show a curve. If you show a fast curve, it won't take as long for the screen to regenerate . . . the curve will show "notched" -- it will look like straight lines.

I: The "jaggies?"

S: Yes. And, if you have a real huge drawing, you can control your view attributes to control how long it takes for a drawing to regenerate.

I: For this particular problem, how did you set the view attributes?

S: [**(16)**Set for the high resolution . . . **(15)**our machines are pretty fast . . . we normally don't get into a drawing that requires the fast display.

I: So for this particular set of drawings you set the curve attribute to high resolution because it doesn't take long for the computer.] What other view attributes did you set?

15. "I use a fast computer for my drawings."

16. "[If 15] I set the resolution to high."



S: [Text nodes . . .which is a little node that you can place text on . . . you just place them in your drawing . . . or whenever you do a paragraph of text, it makes a text node. It's a number that initializes that piece of text.

I: So it's not the text . . . the text actually doesn't show on the screen, just the number?

S: No, it's vice-versa. You can show the number and the text, it's usually where the origin of the text is at . . . that's where the numbers at. It's like if you put . . . the first piece of text you put in, if its a paragraph, it's

number one. And if you put in another, that's number two. And it will number all of those. And you can place them "one, two, three," or you can place the text and it will automatically number them for you. Those little numbers, **(18)**we turn them off **(17)**because we don't want them to plot.]

17. "I don't want text nodes to plot in the drawing."

18. "[If 17] I turn off the text node feature in the seed file."



I: Okay. You just want the text. Why do you use text nodes?

S: I usually don't. But there's nothing you can do to keep it from automatically making text nodes. Because when you make paragraphs, it will automatically make nodes for you.

I: In this particular seed file, did you have text nodes turned on or off?

S: Off . . . so they will not plot.

I: So, for view attributes, you set curve resolution to "high," but you turned text nodes off. What other view attributes did you set?

S: [**(20)**Enter data fields . . . which you can place text and change text . . . they're underbars on a typewriter . . . they're shown as underbars, and you can place text inside there, and you can hit it and change it and do anything you want to it.

I: Why did you use those?

S: **(19)**To place text . . . in a certain point. Like if you make, what we call a cell, then you can place data fields . . . in a typical drawing, you may have a typical detail with different settings on it, like you may have an eighth-inch weld, or a sixteenth-inch weld, you would put a data field there if you wanted to change the weld size. You could place the cell in your drawing, and there would be no

text there . . . there could possibly be no text on it. And then you just pick the data field and place the text in yourself. It's already in a pre-set spot . . . like you the text in a certain spot.

I: Does the data field change when you change different . . . like if you change one dimension, all of the other dimensions change?

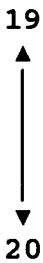
S: No. You have to do that manually. And it's not actually dimension-oriented, it's just text-oriented.

I: Did you set your data fields "on" or "off?"

S: I turned them off. But, we have eight views in Intergraph, and we also have two screens. On the first screen we have view one . . . and that's another view attribute we set, what views we show . . . you can flip screens and show view five. In view five, we have the opposite -- it's either on . . . like the data fields will be on . . . you can go into that view and see them and fill them in, but you plot from view one.]

19. "I want to place text at certain points in the drawing."

20. "[If 19] I turn on the data fields feature in the seed file."



I: [Why do you plot from view one, but have the ability to view the things in another view?

S: So you don't have to go back-and-forth switching these things. **(21)**You can leave them on in view five . . . the things you don't want to plot, but that you'd like to see . . . you can leave them on in view five, **(22)**then you can switch to view one and they'll be off.

I: Is that what you did in this problem? In view five you had stuff turned on, and in view one you had things turned off?

S: Right.]

21. "I want to be able to view data fields only in certain views."

22. "[If 21] I set up my drawing so I can switch between views that have data fields on or off."



I: [View one was the stuff you were plotting, view five was the stuff that you'd refer to, but why would you refer to it in the first place?

S: Well, **(23)**if you had it turned off . . . like an enter data field . . , **(24)**you can't see it.

I: Why would you want to see it?

S: So you could put text in it.]

23. "I turn the data field feature off."

24. "[If 23] then the data fields aren't visible in that view."



I: Why would you want to put text in it?

S: [If you have a data field, it shows as underbars. If you put text in it, the underbars still show . . . and text shows and the underbars show, and you don't want the underbars to show. That's what it turns off. It doesn't physically turn off the text. The text remains.

I: What does the text tell you?

S: Anything you want it to tell you. Like, if you've got a detail and you put, say, four-mil polyethylene, and in another detail . . . you may have the same, exact, detail, but you want four-mil polyethylene in this detail, but you want six-mil in another detail. You would leave a data field there so you could type in "four-mil" in one, and "six-mil" in the other.

I: Who ultimately reads the "four-mil" or "six-mil" type of detail?

S: You plot them and an engineer reads them and checks them, then it goes to the client.

I: When you plot it in view one, but you plot out view five for the engineers?

S: No. No. The data fields, like the text nodes, are system-oriented. **(25)**It shows you the data fields . . . the underbars, so you can fill text in, but you want to turn the underbars off, and leave the text in. **(26)**So in view five, you can see the underbars, cause if you have them turned off, you can't see the underbars. But, the text still shows.

I: So when you plot it, you plot the text, but not the underbars.

S: Right.

I: In this particular problem, when you made the seed file, did you put some text nodes and data fields in, or did you set it up to do one or the other?

S: Just set it up to do that. Because you know it will work out that way.

I: So you set up view one to have the text nodes and data fields turned off, but you had them turned on in view five?

S: Yes.]

25. "I want to set up the drawing so underbars are visible only in some views."

26. "[If 25] I turn off the underbars in view five."



I: What about the other four fields, like two, three, four, and six? How did you . . . did you have them turned on or off?

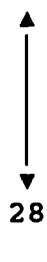
S: You mean the views?

I: Yes.

[(27)S: Usually don't . . . the operator wants to open up another view, (28)they can change it any way they want it.]

27. "I set the drawing up so that the operator can open desired views."

28. "[If 27] the operator can open any view desired."



I: But typically you look at only view one and view five?

S: Usually. Because . . . you can open up more views if you want to . . . that would be operator preference. You try not to anticipate . . . that's one thing -- the seed file is generic, so you don't try to anticipate any particular operator preference. If they want it a certain way, they can change it. But it's usually a general set-up.

I: So, when you set up a seed file, you're not turning on or off the other views, those people can see the other views. But when you're setting up the seed file, you're only concerned with setting up one with text nodes and data fields off, and five with one way or the other?

S: Um, hmm.

I: And in this particular case, you set the curve to high resolution, the text nodes to "off," and the data fields to "off" in view one . . .

S: Um, hmm.

I: . . . and in view five you did the opposite . . .

S: Um, hmm.

I: Then the other four views you didn't set it up at all?

S: Um, hmm.

I: What other view attributes did you set up?

S: [There's a bunch . . . there's several. You can turn your dimensions "on" or "off." That's for speed.

I: What did you do in this particular seed file?

S: **(30)**Left them on in both views. Because you want your dimensions on anyway. Like I said, **(29)**these machines are fast, and you don't have to worry about that.] And you can turn patterning "on" or "off." Like "earth patterning" or "concrete patterning" . . . you can turn that on or off. You usually leave it on.

29. "The computer I use for drawing is fast."

30. "[If 29] I leave the dimensions turned on in both views."



I: That's what you did in this case?

S: [Yes. And we have reference file clips -- we usually leave that "off."

I: What is a reference file clip?

S: Do you know what a reference file is?

I: No.

S: (32)That's a file that's brought in as a background to the other file. You can be working in one file and bring in a floor plan that if you're on the second floor, (31)you can bring in the first floor plan and see what it looks like under there.

I: Like an overlay?

S: Yes. And you can take parts of that out . . . clip out parts that you don't want to see. And you can leave it in your drawing and plot it. That's what we usually do -- if you have a first floor plan and the second floor plan walls are the same . . . we usually use the first floor as a reference file and draw stuff on it.]

31. "I want to bring in the first floor plan as an underlay to the second floor plan."

32. "[If 31] I set up the reference file clip feature in the seed file."



I: It's almost like a batch file -- you have a picture, and you just work from that rather than re-do . . .

S: [Right. You don't have to re-do it. ((33)And that's what the beauty of Intergraph is -- you don't have to update ten drawings (34)if it has that one file . . .) you can update that one file, and all the other drawings will be updated.)] And you can cut out sections of that, if you don't want part of a wall here, you can take it out. But, if you do that in a bunch of different places, you don't necessarily know where you've done it. So, that's why that reference file clip display . . . you can show yourself where you've clipped it out.

33. "I set up the reference clip file."

34. "[If 33] I don't have to update ten drawings."

33



34

[(35)And you don't always want to see that, so (36)you leave it turned off.]

35. "I don't want to see the reference clip."

36. "[If 35] I leave that feature turned off."

35



36

I: So in this particular case, did you turn the reference file clip display off?

S: Off.

I: All views?

S: Yes.

I: Why did you do that for this particular set of drawings?

S: That's usually the way we set it up.

I: That's standard operating procedure and that's why you did that?

S: Uh, huh.

I: What else in terms of view attributes? Any others?

S: No.

I: Let me just go through this again. The first thing you did was consider number of drawings, and you determined you had only a small number of drawings, therefore, you made only one seed file for all five drawings. You set up the parameters which includes setting the lock, setting the

grid, and setting the view attributes. The view attributes included setting the curve to high resolution, setting text nodes off in view one but on in view five?

S: Um, hmm.

I: The data field off in view one and on in view five, dimensions on in both, patterning on in both, reference clip file off in both?

S: Um, hmm. There's also a grid display you can turn on or off, and I turned in off. You set up the grid so an operator can use it, all they have to do is run over and turn it "on."

I: Okay. Why did you turn it "off?"

S: Because most operators, in these particular types of drawings, don't use it. Mostly we use grids in P and ID drawings.

I: What is "P and ID?"

S: That's a piping schematic type of drawing. Some people use grids in all their drawings, but that goes back to operator preference.

I: What did you do after you set up the view attributes?

S: [Well, we also have dimensioning attributes -- a lot of operator preference on that. **(38)**The important thing with dimensioning attributes is that we set up our terminators for our dimension arrows to a certain symbol . . . we have a certain symbol that we use.

I: What symbol did you use in this one?

S: Just a filled-in arrow. Intergraph's default is an open arrow, and those are pretty ugly.

I: You did that because of personal preference or because it is standard operating procedure?

S: **(37)**That's standard for this office.]

37. "I use the office standard for dimension terminators."

38. "[If 37] I use a filled-in arrow for dimension terminators."



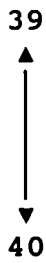
[And you can set the dimension text below the line, above the line, or split the line. **(40)**I set it above the line.

I: Why did you set it above the line?

S: **(39)**That's where we put all our dimensions.]

39. "I place dimensions according to office standards."

40 "[If 39] I place dimensions above the line."



[We can also set the weight of the dimension lines.

I: At what did you set the dimension weight?

S: **(41)**Zero, which is a real thin weight . . . and the text and the dimension lines to a weight of "one," which is just a little bit heavier. **((42)**The text will stick out from the lines, and that's drafting procedure there . . .) that's standard drafting procedures there.)

I: And you did that for this seed file?

S: Yes.]

41. "I use standard drafting procedure and set the weight of dimension lines to a weight of one."

42. "[If 41] the text will stand out from the lines."



I: Any other dimensioning attributes?

S: That's all I set up. And you have text attributes, which are usually pretty simple. There's a certain font we use . . . a font of one. It's just how the text looks . . . you have Greek fonts and Old English fonts, font one is just the standard font we use. That's our standard operating procedure. A font of one, with the text origins at the upper left-hand corner.

I: What do you mean by text origins?

S: Like when you place the text in a drawing, your text, where you place it, will be in the upper left-hand corner. That's standard.

I: Did you do that for this seed file?

S: Yes.

I: What did you do after you set up text attributes?

S: That covers everything that we take care of.

I: And that's what you did in this particular project?

S: Yes.

I: Okay. Let me just summarize, real quick, what you did. The first thing that you did was consider the number of drawings. You made one seed file because you determined that five was a small enough drawing to make one seed file. You set up the parameters, which included setting up the locks, and you do that because it's easier to do the drawing -- it's kind of a batch file. You set the grid, and you set the grid in this case to one-eighth inch. The reason being that, for these types of drawings, that's standard procedure. You set the view attributes, and that included setting the curve to high resolution, text nodes off in view one and on in view five, data field off in one and on in five, dimensions on in both, patterning on in both, grid display off in both, reference clip display off in both. Then you set the dimension attributes, which included things

like arrowheads, and the reason you chose the type arrowhead you did was because in this office you guys determined this is the better-looking type of arrowhead to use. You set dimensioning above the line. Why did you do that?

S: That's our standard.

I: Then you set text and line weights. Text is a weight of one, line is a weight of zero. You did that is because it is standard drafting procedure. Then you set text attributes to one which is another Stone and Webster standard. Is that everything?

S: You also set text justification . . . where the origin is.

I: Upper left?

S: Yes.

I: And that, again, is Stone and Webster's rule-of-thumb.

S: Yes.

I: Okay. Thank you very much.

Subject 2
Problem 1
Interview 2
ANALYSIS

Problem 1

Interviewer: Okay, you've looked at the expert system program and the hypertext program. I'm going to interview you on the same problem, asking you how you would solve the problem if you were to have that problem a second time. What is the first thing that you'd do in setting up the seed file or files?

Subject: Basically, just see what the job required . . .

I: What do you mean by "seeing what the job requires?"

S: See if they have any specific standards. If you have to go by a company's standards, or if you can just use Stone and Webster's corporate standards.

I: How do you determine whether to use the client's standards or Stone and Webster's?

S: [Basically, when you start the job, you know who the client is you're starting the job for, you ask them, first, (1)if they have CAD standards. (3)If they don't, (4)they normally give you the free hand to do it your way, so that's when we'd incorporate Stone and Webster's standards. (2)If they have their own CAD standards, we just have them send them to us, and we use those.]

1. "The client has CAD standards."

2. "[If 1] I use the client's standards."



3. "The client doesn't have CAD standards."

4. "[If 3] I use our company's CAD standards."



I: So, if they have standards that they'd make available to you, you use the client organization's standards, and if they don't you use Stone and Webster's standards.

S: Um, hmm.

I: What do you do after you determine which standards you're going to use?

S: [Then you can begin setting up your seed file. (5)With a small number of drawings like that, (6)you'd probably use only one file.

I: So you'd set up your seed files, or file, and, again, using the parameters of this problem, there were five drawings, so you set up only one seed file. If you have quite a few drawings, would you set up more than one?

S: Probably, because when you have a case, like different drawings . . . electrical, mechanical, you usually do have different parameters for your files. But with a small job like that -- just five drawings -- you would set up one seed file and each person could go in and, there's usually just small changes . . . in dimensioning, or grid, or . . . something just minor. If you've got a whole lot of drawings that are going to be in it, it would be worth the time to go ahead and just set up a seed file for each discipline.]

5. "I have only five drawings to render."

6. "[If 5] I set up only one seed file."



I: So you determine the standard, you set up one seed file -- you determine that if there are only five drawings, you

set only one seed file. What's the first thing you'd do to set up that one seed file?

S: [You'd go in, open up the seed file, then -- there's not any specific order -- (8)you'd attach the border for that particular job. And set up your text fonts . . . and you could set up your dimensioning attributes, how you want those to come out . . . you have specific line weights for lines, and specific weights for the text we use.

I: Are those Stone and Webster standards?

S: Yes. Those are basic . . . (7)those are kind of drafting standards . . . pretty basic, even among corporations.]

7. "Drafting standards exist."

8. "[If 7] I use drafting standards as I set up the seed file."



I: [If drafting standards exist, you'll use the drafting standards. What (9)if drafting standards don't exist for some of these dimensioning attributes? What do you default to, then?

S: A lot of it would be . . . what we try to do . . . we would like to have user preference. How the user would like to do it. But if you do that, you have inconsistent drawings. (10)So we usually determine one way to do it . . . if there's a gray area, everyone gets together and determines how they're going to do it, and everyone agrees to do it the same way.]

9. "Standards do not exist for some drafting attributes."

10. "[If 9] individuals in our organization reach consensus on a standard for those drafting attributes."





10

I: So, if no standards exist, for a dimensioning attribute, the workers at Stone and Webster get together and come up with a de facto standard?

S: Right. And everyone goes back, because that's the last thing we want -- inconsistent look in the drawings.

I: [You mentioned when you open a seed file and set up attributes, there's no specific order. What order do you use? What order would you use with this problem?

S: Probably the order I'm giving you.

I: The order you've given so far is: attach the border, set up the text fonts, set up the dimensioning attributes. Why do you use that order?

S: (12)It's just what you're used to doing first. (11)The reason it doesn't matter what order is because none of it's tied together to where you . . . it's not where you have to go in, like working on a car, to get to a piston you have to take the head off first. It's not dependent on an order. It's usually just whatever you think . . . you're sitting at your desk, and you think, okay, I have to do this . . . and you just do it. I need to do that, so you do that. Sometimes you even do it different yourself . . . in different order. So, just whatever you decide to do.

I: So, if the parameters you're setting up are not interdependent, then you can use personal preferences in setting up.]

11. "The order of setting attributes in the seed file is inconsequential."

12. "[If 11] I set the attributes according to my preference."

11



12

S: Um, hmm.

I: Just to summarize what we've got so far: you determine what the job requires, in terms of whether you're going to use client standards or Stone and Webster standards. Then you set up the seed file. You determined that with this number of seed files, five, you're going to set up one seed file. Is there a cut-off point at which you'd look to set up more than five, or is it dependent on the type of drawings or . . . how does that work?

S: [(13)It would depend on the type of job. Sometimes we get just like a mechanical job, and most of it would just be dependent on minor mechanical drawings. (14)And sometimes we get jobs that have everything in it.

I: So, if it's all mechanical, regardless of how many drawings you might have, you'd set up just one seed file?

S: Correct.

I: But if it's a number of different types, you might set up a number of different seed files?

S: Um, hmm.]

13. "I determine whether the drafting job I'm doing is of one or many types."

14. "[If 13] I determine how many seed files are necessary."



I: Then you open the seed file and set up your attributes. Those attributes are not interdependent, so it's a matter of your personal preference and, typically, you attach the border first, set up text fonts, and set up dimensioning attributes. Both your text fonts and dimensioning attributes depend, most of the time, on drafting standards. Most companies use the same standards.

S: Um, hmm.

I: However, when those standards don't exist, Stone and Webster employees get together and determine de facto standards so the drawings have some consistency.

S: Um, hmm.

I: What would you do next to solve this problem?

S: [(16)Set up our locks. Set up certain locks.

I: Explain that.

S: It's usually . . . a lock is just a . . . one lock is just a snap lock, which is something we always have on. (15)You can make a point on the very end of the line that snaps to the end of the line, which is very simple and basic, but is very handy. If you want to place a line from the end of another line out so far, you just can snap to the end of that line without having to do anything special, to go exactly on the end of that line.

I: So, you set up locks, and one of the types of locks is a snap lock. And one of the reasons you'd set up a snap lock is for more accurate line drawing?

S: Um, hmm.]

15. "I want to be able to draw accurate lines automatically."

16. "[If 15] I set up the snap lock feature."



I: [What are some of the other locks?

S: (18)We have, another thing that's tied in with the snap, is the key point number. You would put it in . . . standard is key point "2." It divides a line up in two places. So you can key in any number: two, ten, twenty . . . it will divide that line you're snapping to into segments. So if you want to draw from the middle of a line, you key in "2" and it will snap to the center. You usually use that . . . that's always saved, we usually save that. So, it will be in the seed file.

I: (19)You do that so you can more accurately draw from the mid-point or wherever you might want to draw another line . . . another 90° from?

S: Right.] And we always have our text node locks. That's a display attribute; that's not necessarily a lock. We don't worry about the display attributes. A snap lock are usually the only ones to save. Some of the other locks are user preference, and if they want it on their particular drawing, they can set them up in their own drawings. But the seed file really doesn't have anything to do with another drawing . . . it's just like a copy of something . . . underlying standard . . . like a basic . . . like if you have a basic program, and you want to take out a part and add your own to it, that's basically what a seed file does.

18. "I want to draw 90° lines from a reference line."

19. "[If 18] I set up the key point feature."



I: What does the text node refer to?

S: [That's in the displays . . . that's another thing we want to set up, is our display attributes. Display attributes . . . (21)you'd have text nodes would be "off." Like I said, each time you want to place a paragraph of text, there's a number associated with that paragraph of text . . . it's called a text node. If you have your text nodes "on" it shows that little number, (20)and you don't want that little number to plot. All it is . . . it's intelligence to the text. You can key in that text node number and do things . . . do certain things to it. But you don't want that to show, you want that to disappear. So you turn that off in your drawing. And you turn those off . . .] [(23)and, usually, you leave the grid off, too. You can have a grid, and you can set up for certain spacing. (22)Leave the grid off. That's just part of the display.] [And your curves . . . (25)you want what's called "fast curves" . . . and ((26)fast font, (27)which doesn't show the font chalked-up,) (24)it doesn't show the curve chalked-up. It displays faster than if you have the slow curves, and the curves instead of being a curve, it looks like lines. That's just for faster display. But you don't want it to plot like that. You want it to plot a curve as a curve.]

20. "I don't want text node numbers to plot."

21. "[If 20] I turn off the text node feature."



22. "I don't want a grid to display on the drawing screen."

23. "[If 22] I turn the grid display feature off."



24. "I want the curves to display on the screen quickly."

25. "[If 24] I turn on the 'fast curves' feature."



26. "I want the fonts to display on the screen quickly."

27. "[If 26] I turn on the 'fast fonts' feature."



I: [Some of the display attributes are for efficiency, so the screen refreshes pretty quickly and you don't have to

wait for it to plot on the screen?

S: Right. (28)But we usually . . . that only comes into play, computers have gotten so fast and (29)it takes a pretty big file for you to need to do that. So that's why we always set up our seed files showing it the way it's supposed to be.

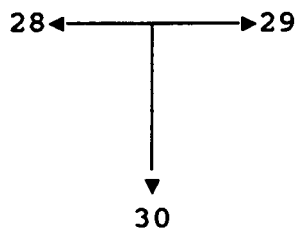
I: The rule here would be "If it's a large file that would take a long time to refresh on the screen and display, you'd use that attribute where it would show lines rather than the smooth curves." But typically, you guys use the smooth curves.

S: We rarely get a design file that large. Like I said, the computers we have now are pretty fast. (30)We don't normally have to worry about that.]

28. "The computer I'm working with is fast."

29. "The design file I'm working with is not large."

30. "[If 28+29] I use the 'slow curve' attribute."



I: Is it critical about when you set up the display attributes, or is that one of those things where you can set it up . . .

S: All of it is in no particular order.

I: Okay. So you determine the client's standards or whether you'll use Stone and Webster's standards. You set up the seed file; for five drawings you set up only one. You open the seed file and attach the borders. Set up the text fonts. Set up the dimensioning attributes. Set up the locks and display attributes. What would you do next?

S: That's pretty much got it for the seed file. Everything else, basically that's how the user wants to do it. What the seed file does, is it just gets you started.

I: Very good. Well, I sure appreciate your time.

Subject 1
Problem 2
Interview 1
ANALYSIS

Problem: Design a 3D office layout within a 12 x 14 foot office.

I: When did you first begin to solve the problem?

S: Yesterday.

I: When did you finish it?

S: About ten minutes ago.

I: About how long did you work on the problem?

S: Probably an hour, at the most.

I: What's the first thing that you did?

S: Well, I thought, "this is my office, I'll do it right."

I: So the first thing you did was assume it was going to be for you? (Subject shakes head affirmatively) What's the next thing that you did?

S: [**(1)**Well, I like a lot of light so I allowed a curtain wall along the other side . . . **(2)**put a bunch of windows in one side.

I: Okay. And you did that because you like a lot of light?

S: Yeah. It keeps me happy.]

1. "I wanted a lot of light."

2. "[If 1] I placed a lot of windows on one wall of the office design."



I: After you designed the windows on one wall, what was the next thing that you did?

S: [The type of lighting . . . I had to arrange the lighting.

I: Overhead lighting?

S: Uh huh.

I: And how did you do that?

S: (3)I ran it across the narrow part of the office -- perpendicular to it . . . parallel to the narrow dimension, twelve feet.

I: And why did you run it across the narrow dimension of the office?

S: (4)So the light would disperse better and be high on the walls.]

4. "[If 3]I design the overhead lighting to run perpendicular to the narrow dimension of the office."

3. "I want the light to disperse better and disperse high on the walls."



I: Did you use any particular kind of lights?

S: Recessed incandescent.

I: Why did you use recessed incandescent lights?

S: That's just my favorite.

I: Personal preference?

S: Um hmm.

I: What is it about recessed incandescent lights that you, in particular, like?

S: Just flush . . . I don't like them protruding down.]

I: Okay. After you designed the lighting, what did you do next?

S: Determined the type of furniture I need.

I: Okay.

S: A desk, reference table, filing cabinet, book-shelves . . .

I: Desk, reference table, bookshelves . . .

S: Filing cabinet.

I: Okay, what else?

S: Of course, telephone, computer, printer.

I: Is that pretty much it?

S: Yeah.

I: Any particular kind of desk?

S: Executive desk.

I: And why did you choose that kind of desk?

S: Personal preference.

I: What is it about an executive desk that you personally like?

S: It sets off the image that I know what I'm doing.

I: Alright. And what is a reference table -- I'm not familiar with that term?

S: Just, really a table with no drawers or anything in it . . . to lay stuff out, spread papers out.

I: Okay. When you designed this office for yourself, did you assume that you'd still be doing the same job you have now -- design work, that kind of thing? What would you be doing if you had this office?

S: Systems Administrator.

I: And, so, when you're using a reference table, you're using it as a Systems Administrator . . . "big shot" kinds of things?

S: Yeah.

I: You mentioned bookshelves. Why would you need bookshelves?

S: Reference manuals.

I: Is that something a Systems Administrator would have a lot of call for?

S: Um hmm.

I: File cabinet . . . how many drawers would your file cabinet have?

S: At least four.

I: And . . .

S: Lateral.

I: Lateral file rather than a vertical file. Why would you pick lateral rather than a vertical file cabinet?

S: They hold more and they . . . well, they take up more room along a wall, but they're not near as deep as far as sitting on the floor.

I: Okay. And you'd have a phone for communications. What would you use your computer and printer for?

S: Writing and printing up reports, database entry, loading in . . . corporate communications.

I: When you did the design of your office and put the furniture in, did you size the furniture in relation to the size of the office?

S: Yeah.

I: For instance, what size would your executive desk be?

S: I didn't measure it.

I: So you didn't measure it, but you actually placed it on your drawing?

S: Yeah.

I: What was your thought process when you placed the furniture -- why did you put the furniture where you put it?

S: [(6)Well, again, that's why I was concerned about the lighting. I'm the type of person that kind of likes it diagonal . . . (5)so that things sit diagonally to reduce the amount of shadow you project on your table. So I put it diagonally.]

5. "I want to reduce the amount of shadow projected by the lighting."

6. "[If 5] I design the lighting to be oriented diagonally to the furniture."



I: So, like kind of coming out of a corner rather than flush against a wall, that kind of thing?

S: Um hmm.

I: Where did you put your desk in the office? Did you put it in a corner or against a wall?

S: It sits diagonally.

I: I notice your door is set very close to one of the walls. If you walk straight through the door back to the corner opposite along the same wall as the door, you'd come to the corner of where that desk is.

S: Right.

I: So if your door . . . let me see how this would work . . . southwest corner, your desk would be in the northwest corner.

S: Right.

I:[(7)Why did you put the door where you put the door?

S: No particular reason. (8)I'm left-handed when I reach for a door handle. So when I reach for the door handle with my left hand, I push to the left.]

7. "I want to be able to open the door with my left hand."

8. "[If 7] I place the door handle where it is convenient to open it with my left hand."



I: Where would you put your reference table?

S: Right back here.

I: So it would be right . . .

S: No . . . that's my filing cabinet -- I made a mistake. The reference table is right here.

I: Your reference table is approximately center of your eastern wall, your file cabinet is approximately the center of your southern wall. Why would you put those where you have those?

S: I like that arrangement.

I: Personal preference?

S: Yeah.

I: How about your computer and printer? Do those go on your desk, or . . .

S: Yeah, on the desk. Laptop.

I: A laptop! So, you can carry it with you. Why would you choose a laptop?

S: Pure convenience. More desk space.

I: So the first thing you did was make an assumption that the office was going to be for you, that you would be a Systems Administrator. The first thing you designed was the full wall of windows along the northern wall. The next thing you did was the overhead lighting which you ran across the narrow dimension of the office, and you did that for dispersion of the light. You decided to use recessed incandescent lighting which is flush to the ceiling, which is your personal preference -- to have lighting that's flush. Then the next thing you did was determine what kind

of furniture to put in your office. And you included an executive desk because of the image it projects, the reference table for spreading out your work, bookshelves to hold your reference manuals. Where on your drawing did you put your bookshelves, by the way?

S: On this wall.

I: So, about the center of the west wall -- not quite the center of the west wall. Your filing cabinet would be at least a four-drawer lateral rather than vertical file cabinet. Then you'd have the phone for communications. You'd have a computer, which would be a laptop so it would take less space. You'd have a printer so you could print reports, use it for database input, and modeming. What did you do after you determined what furniture you wanted?

S: That's when I placed it in . . . got the right arrangements.

I: I notice you have a hand-rendered drawing here. Did you do only sketching to design this or did you . . .

S: This is my preliminary sketching, and I did it on a computer.

I: Oh, you did do it on a computer, as well?

S: Uh huh.

I: What computer program did you use?

S: Intergraph. Project Architect to print the walls.

I: Why did you use Intergraph?

S: That's about all we use . . . I'm most familiar with that software.

I: When you took the preliminary sketch and put it in the computer, what's the first thing that you did?

S: [Well, I already had a project started, so (10)I just created a new drawing in that project.

I: Created a new drawing in an existing project. Why did you do that rather than start a new project?

S: (9)Since there's really only one quick design, I didn't want to go through the procedures of creating a new project which entails time and tying a database to it. So, it just cut down on time.]

9. "The office drawing involves one quick design."

10. "[If 9] I can draw the design into an already existing drawing."



I: What was the first thing you did to render the drawing, itself?

S: Laid out the walls and set out all the variables. Laid out the square room and laid out the curtain wall in the north end of the room. Then put the door.

I: So, in the actual drawing, you laid out the walls first. Then you put the windows. Then you laid out the door. What did you do next?

S: Attached the cell library where all the model furniture is.

I: Okay. Then what did you do?

S: Went through and found the desk and reference table and all the furniture I like. Executive desk, lateral file cabinet.

I: What did you do after you picked out all the furniture?

S: [**(11)**I placed them in. Then, once I had them all in, **(12)**I could move them around and rearrange them the way I wanted.]

11. "I place the furniture in the drawing."

12. "[If 11] I can rearrange the furniture in the drawing."



I: Okay. What kind of considerations did you use when you placed the furniture?

S: Well, lighting, for example . . . diagonal. Pure convenience of coming in and out. Room for the chair to roll around and people to come in.

I: So, you placed the furniture, then what did you do after you placed the furniture?

S: [(14)I modeled up the walls. Played around with it a little bit.

I: What does "modeling up the walls" mean?

S: (13)Well, when you initially lay out the walls it's on a flat, 2D plan. So you have to go through a little series of commands to cut a section and an elevation of a building, then it will project them up.]

13. "I wanted to render a drawing with elevations."

14. "[If 13] I modeled up the walls by typing in the appropriate commands."



I: Then after you modeled up the walls, what's the next thing you did?

S: That's about it. Spun it around and looked at it.

I: So, you looked at it?

S: Yeah. Shaded it and all that.

I: What do you do when you shade a model like that?

S: You arrange the wire frame in a good looking angle to look at, and then just pull the render dialogue box and tell it what kind of shading you want: shaded, stereo, full hidden line . . . there's various types.

I: Which way did you shade it?

S: (15)Full hidden line.

I: Why did you choose that?

S: (16)That still leaves the image. You can still see the edge of the walls and the corners of the walls, and the wall coloring. So you can still see the image.]

15. "I want to develop a drawing in which you see the edge and corners of walls and the wall coloring."

16. "[If 15] then I render the drawing as a full hidden line drawing."



I: So, that's the last thing you did, the shading?

S: Um hmm.

I: Well, thanks very much.

Subject 1
Problem 2
Interview 2
TRANSCRIPT

I: I'm going to ask you about the same problem you solved originally -- that you need to design an office. What is the first thing that you'd do?

S: Given the criteria of the sizing, I created the design file in "Project Architect."

I: Why would you create a design file in "Project Architect?"

S: "Project Architect" is the environment in which we design floor plans, and so forth . . . and the design file is the actual design itself.

I: So, the design file is basic to the creation of the rest of the design?

S: Um, hmm.

I: What goes into the creation of the design file?

S: Anything and everything -- all the walls, windows, doors, furniture . . .

I: What is the first thing you'd do in creating the design file?

S: Enter through "Project Architect" and create a design file.

I: Okay, how would you create a design file? What's the process that you'd use?

S: Once you get into the "Project Architect" environment, you have several menu options. One is to create a design file. Fill in the file name, and it will make it.

I: Okay. So you fill in a file name and it creates a file. What do you do after you create the file by typing in the name? What's the next step?

S: The computer creates it, then you have the choice of going on and entering into it.

I: What is the first thing you'd enter into the design file?

S: Start making the walls, given the criteria of the 12x10.

I: Okay, so the first thing you'd do after the design file is created, is to create walls for a ten foot by twelve foot environment.

S: Um, hmm. Assuming four inch thick walls.

I: Okay. Then what would you do?

S: I'd pick the command to pick walls by shape. Because in essence, you can draw a square . . . two-point square.

I: So, you click two points on the computer screen . . .

S: Diagonal points being ten by twelve foot apart, so I could put one point anywhere and the next point I would key off ten dimensionally ten feet in the x direction and twelve feet in the y to a diagonal point will make a ten by twelve room.

I: And you do that by using a digitizer?

S: Um, hmm.

I: Is there a grid on the screen that you snap to? Is that how you create the points?

S: Um, hmm.

I: [**(1)**After you create the walls . . . are you creating a floor plan or elevation at that point?

S: **(2)**Floor plan.]

1. "I create the walls in the drawing."

2. "[If 1] I can create the floor plan."



I: What do you do after you create the walls by finding the x and y coordinates?

S: Locate the doors and windows.

I: What process would you use in determining how to design the doors and windows into the office?

S: [(4)I particularly like to place a three-foot door?

I: Why a three-foot door?

S: (3)Roomy. I hate small doors.]

3. "I want to design a 'roomy' door."

4. "[If 3] then I design a three-foot door."



I: Where would you place that three-foot door?

S: [(6)In the corner . . . ((5)to provide more wall space for one thing and) . . . usually opposite the wall with the windows.]

5. "I want to provide maximum wall space."

6. "[If 5] I design the door to be in a corner opposite the wall with windows."



I: Which wall would the windows be on?

S: Depending on what the exterior wall was, but I assumed it to be the ten foot wide north wall.

I: So, you made an assumption that the window wall . . . the exterior wall, would be the ten foot wide north wall, therefore your door would be a three foot door on the south wall . . .

S: Southwest corner.

I: What would you do after you locate your door and your windows, what would the next part of your design be?

S: [Play with some furniture layouts by attaching a cell library with all the furniture in it.

I: What is a cell library?

S: Its a file that holds all the symbols for desks and chairs and other . . .

I: (7)So, if the cell library has the graphics of the furniture already drawn, (8)you just choose the furniture you want?

S: Right . . . like to place.]

7. "The cell library has graphics of furniture already drawn."

8. "[If 7] I choose the furniture I want for the drawing from the cell library."



I: How does that work? How do you actually pick furniture from the cell library? Do you open a file and see all the pictures?

S: You can do what they refer to as "show library," which is your cell library attached, and it will show graphic representations of each cell. It works a lot like "Windows." You scroll through and pick one and it will show it to you.

I: When you see a picture you like, what do you do then?

S: Select it as the active cell and insert it.

I: [So, you choose it via the digitizer and insert it into the drawing. Do you make a conscious effort to place the picture where you want it, or just bring it into the drawing and drop it?

S: I generally get it reasonably close.

I: **(10)**Do you continue to do that process until . . .

S: The office fills up.

I: **(9)**So, you see how large the office is and that determines how much furniture you put in?

S: Um, hmm. I furnish it with what I want, first of all.]

9. "I determine the size of the office."

10. "[If 9] I fill the office drawing with furniture until it is full."



I: Okay. What are the assumptions you're making about what kind of office you'd want?

S: I'm assuming its for me later on in my career in a management position, so I kind of select furniture that would allow me plenty of storage room, yet versatility . . . like for computer equipment.

I: Let's talk about what type of furniture you'd populate the office with. What would you put in there?

S: Nice desk and a comfortable chair.

I: What is your definition of a nice desk?

S: Good storage capability.

I: Okay. What's good storage capability?

S: Center drawer and both sides, drawers.

I: How do you define a "nice chair?"

S: Supportive . . . back supportive . . . maintain my load.

I: What else would you put in besides a desk and a nice chair?

S: [(6)I find that a lateral file cabinet might take up more wall space, (5)but less floor space away from the wall that is helpful and has plenty of storage.

I: You'd choose a file cabinet, and the reason you'd choose a lateral file over a vertical file is because it takes up less floor space?

S: Away from the wall, in that direction.]

11. "I want a file cabinet to take up less room in a vertical direction from the wall."

12. "[If 11] I choose a lateral file cabinet rather than a vertical file cabinet."



I: Okay, you've got a desk, a chair -- a good supportive chair -- a lateral file cabinet. What else would you put in in terms of furniture?

S: Bookshelf, to hold reference manuals.

I: Any particular size of bookshelf?

S: **[(14)**Four-by-six.

I: Why that size?

S: **(13)**Hope to need a lot of reference manuals.]

13. "I need space for a lot of reference manuals."

14. "[If 13] I put a four-by-six-foot bookshelf in the design."



I: What kind of reference manuals would you put on your bookshelf?

S: Well, based on what I'm hoping to get into, mostly computer type reference manuals.

I: What kind of assumptions are you making about what type of computer programs a manager would use?

S: Definitely going to have to have "WordPerfect." And probably some kind of tracking software; maybe even "Lotus."

I: Spreadsheet?

S: Um, hmm.

I: Anything else?

S: Other than project planning and "Lotus" and "WordPerfect," not right off the bat.

I: Okay. Any other furniture other than the desk, the chair, lateral file, and bookshelf?

S: [**(16)**Yeah, have to have a guest chair.

I: Why would you need that?

S: **(15)**Meetings.]

15. "Meetings will be held in the office."

16. "[If 15] a guest chair is placed in the office design."



I: Anything else?

S: Maybe a board to hang on the wall.

I: Like a white board?

S: Yes.

I: Let me summarize what we have so far. In designing your office the first thing you'd do is create a design file in "Project Architect," and you'd create that design file by clicking on the menu item in "Project Architect." "Project Architect," as I understand it, is an "Intergraph" application. "Intergraph" is the CADD program you guys use at <company name>. The first thing you'd add are your walls, then your windows, doors, and furniture. The walls would be for a ten by twelve foot environment and four inches thick. You'd locate your doors and windows next. You'd like a three foot door because you like a nice, wide, door. You'd place it in the corner of the southwest wall, because an assumption your making is that the north wall is the exterior wall and you want to place windows in that wall. The next thing you'd do is lay out your furniture via your cell library. The cell library is a library that has furniture already drawn in it and you can click on the pieces you want and place it in your design. Your desk would be good size with good storage. It would have drawers in the middle and on both sides. Your chair would be a nice chair. It would be supportive -- it would have a supportive back. You'd have a lateral file cabinet. The reason you'd have a lateral file rather than a vertical file is that it takes less floor space coming from the wall -- it takes more space width-wise, but less coming vertically from the wall. You'd also have a bookshelf for reference manuals. The bookshelf would be four by six. The reference manuals would be software documentation that you'd use as a manager including "WordPerfect," "Lotus," and a project planning software program. You also want a guest chair for meetings and a white board. What would you do after you've populated the office with furniture?

S: I would project the walls into 3-D.

I: Is that an elevation?

S: An elevation, um, hmm.

I: Okay. How do you do that?

S: You have to define the elevation view and which direction you're looking in and how deep you're looking.

I: How do you do that in the program? Do you key in some specs?

S: You'd click off the menu options on the screen that would place an elevation section cut bubble to define the direction of view. Then it would prompt you for the depth of your view in cone. In this case I'd generally enclose

the whole office to get the depth of the office to project all the walls.

I: What would you do after you've projected the elevation in 3-D?

S: [**(17)**Make sure I'd like the office arrangement, furniture-wise.

I: What would you do if you didn't like the way the furniture was placed?

S: **(18)**I'd move it around until I like it. Like the way you come in and out to the desk from the door.

I: So your criteria for appropriate office placement would be traffic flow and accessibility?

S: Um, hmm.]

17. "I design arrangement of furniture in the office design based on traffic flow and accessibility."

18. "[If 17] I move furniture in design to accommodate flow."



I: Anything else?

S: I'd have to spin it around and look at it in 3-D and shade it.

I: What does shading do to the drawing?

S: You're always looking at wire frame, so shading will add color to give you the feel for depth.

I: So, wire frame is the outline-type of programs that a lot of people are familiar with seeing . . . or CADD drawings that people are used to seeing that look like hand rendered drawing, but shading adds depth and feel to it . . . color?

S: Um, hmm.

I: Anything else?

S: Spin it around.

I: Look at it from different angles?

S: Um, hmm.

I: Why would you look at it from different angles?

S: Always like to do that . . . pretty interesting.

I: Okay. Thank you very much.

Subject 2
Problem 2
Interview 1
ANALYSIS

Problem: Design a 3D office layout within a 12 x 14 foot office.

I: When did you actually start to work on this problem?

S: One day last week.

I: And when did you finish?

S: Just a few hours after I started . . . two or three hours.

I: Okay. What's the first thing that you did?

S: I used this for notes . . . Do you want to know how I did it with the software, or . . .

I: Right from scratch . . . right from the start.

S: [Okay. The first thing I did was, (1)I laid out the basic walls . . . the outline of the office, using the twelve foot by fourteen foot inside diameter . . . inside measurements.)]

I: Did you do that on paper or on the computer program?

S: On the computer.

I: Why did you use inside dimensions?

S: [Uh, (2)so the measurements would come out better . . . easier for me.]

1. "I laid out the outline of the office using inside dimensions."

2. "[If 1] then the measurements would be easier to work with."



I: And how did you lay it out on the software program itself?

S: [(3)We have a special architectural program that you build walls with, and doors . . . (4)lays walls in and doors . . . gives you double-line walls automatically.]

I: Is double-line the state-of-the-art in drafting . . . two lines for a wall?

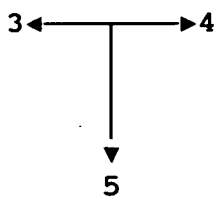
S: [(5)That's pretty much state-of-the art, but this is also a 3-D design package, also. So it will give you a 2-D plan drawing, then when you get ready to take it into 3-D, it can be converted and it will convert everything into a 3-D picture for you.]

3. "I used a special architectural program."

4. "[If 5] the program lays in walls and doors and gives double line walls automatically."



5. "[If 3+4] the drawing can be converted from 2-D to 3-D."



I: [(6)Did you have a choice of software packages to use?

S: No.

I:(7)So, the reason you used that particular 3-D package is that's what's available here?

S: That's what we had access to.]

6. "A choice of design programs was not available."

7. "[If 6] I used the program that is the company standard."



I: And so, the first thing you said you did was to lay out the basic walls, the twelve-by-fourteen using this architectural software. What did you do after you laid out the basic outline?

S: [(8)Okay. Then I put a three-foot door in, at the front of the office . . . about six inches off one wall. (9)And, uh, that was so, when you push a door close to one wall you get a lot more wall space. You don't want to split a room with a door, because you've ruined that one wall.]

8. "I designed the door six inches from one wall."

9. "[If 9] more wall space is available."



I: Why did you use a three-foot door?

S: That's . . . basically, for office buildings and commercial stuff, that's code, because it has to be big enough for handicapped.

I: So you used a three-foot door because it meets code and because it is handicapped accessible. You put it six inches off one wall so that way you'd have more wall space.

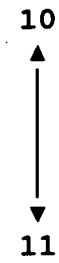
S: Um, hmm.

I: What did you do after you put the door in the design?

S: [(11)Then I put in windows on the back wall that (10)I would assume is the outside wall, across the whole back wall.

10. "I assumed the back wall is an outside wall."

11. "[If 10] I designed windows into the back wall."



I: So you put windows in that went from one end of the wall to the other end?

S: Um, hmm.

I: Any particular size?

S: **(12)**They're three-foot wide. I could have made them any height. **(13)**I probably would set them off the floor two-and-a-half feet, maybe three.

I: Why would you use those dimensions: three feet wide and two to three feet off the floor?

S: **(14)**I used four windows and it came out twelve foot on the back.

I: That's why you used three-foot windows. And why would you set them two to three feet off the floor?

12. "I designed windows three feet wide."

13. "[If 12] four windows across the back wall would cover the wall and come out evenly."



S: **(15)**So you could, if you wanted to slide a desk under it you could. See, our windows here go almost all the way down to the floor. You can't really put a desk up against it because it really doesn't look good.]

13. "I designed the windows to be two-and-one-half to three feet off the floor."

15. "[If 13] you could slide a desk under the windows."



I: Okay. So the reason you put windows along the back wall is because you assumed that would be an outside wall?

S: Um, hmm.

I: What's the next thing that you did after you put the windows in the office?

S: Then I started populating the office with furniture -- I put quite a bit of furniture in it.

I: What furniture did you put in?

S: I put a three-foot by six-foot . . . executive desk -- has drawers on both sides. And then I put an executive high-back chair. And a fifteen inch by five foot credenza. And a two-drawer lateral file. And I put trash can in, and a telephone, and a . . . put a two-foot-six by five-foot desk. And on top of that I put a computer and a printer. And I also put a plant in it . . . had some plants, so I put a plant in it. And a guest chair in front of the desk.

I: Anything else in terms of furniture?

S: Hmm-um. That's about all I could get in.

I: I have a number of questions about the furniture. One is just a general question: why did you choose all this furniture in terms of what kind of assumptions you made about who was going to use the office?

S: [**(16)**What I did was just assumed it would be . . . I kind of fixed it up because I figured it would be a managerial-type person. **(17)**And they would need a lot of storage space, a lot of file space. That's what the lateral file and the credenza are for.]

16. "I assumed the office would be used by a manager."

17. "[If 18] there would be need for storage space and file space, and a lateral file and credenza could provide that space."



I: The reason you put the fifteen inch by five foot credenza and the lateral file cabinet is for storage space?

S: Um, hmm.

I: [**18**)Why did you use a three-foot by six-foot executive desk?

S: (**19**)That's a nice size, good looking desk for a manager.]

19. "I wanted a nice sized, good looking desk in the design."

18. "[If 21] I used a three-foot by six-foot executive desk in the design."



I: [(**20**)Okay. You mentioned specifically, too, that it has drawers on both sides. Is that a factor, also? Was that for storage?

S: Um, hmm -- (**21**)for storage also.]

21. "I wanted a desk with storage space."

20. "[If 21] I used a desk with drawers on both sides in the design."



I: [**(22)**Why the executive high-back chair?

S: **(23)**Nice chair for the manager.]

23. "I wanted the design to include a nice chair for the manager."

22. "[If 23] I included an executive high-back chair in the design."

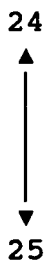


I: Trash can is pretty obvious. Phone . . . [**(24)**Why did you put a two-foot-six inch by five-foot desk with a computer and printer?

S: **(25)**That's for the forward-going manager person. The one that knows how to use a computer and uses it and has a printer to do it with. Which is getting to be more and more popular and regular . . . You see that a whole lot more now.]

25. "I assumed the manager would have use for a computer and printer."

24. "[If 25] I included a computer and computer furniture into the design."

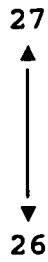


I: [(26)What about the plant? Why did you place the plant?

S: (27)That's basically for aesthetics.]

27. "I wanted to include aesthetics in the design."

28. "[If 27] I placed a plant in the design."

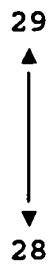


[(28)I: And the guest chair?

S: (29)That's for if you have a visitor. You want them to be able to sit down.]

29. "I assume there will be visitors to the office."

28. "[If 29] I put a guest chair in the design."



I: What about the arrangement of the furniture?

S: That had to be taken into consideration. [(30)You need to have . . . you need to have close to three-foot space for, in your traffic area.

I: Why do you need three-foot . . .

S: (31). . . for basically the same reason as the door. You need to have that much for handicap accessibility. And you don't want to be, even if you're not handicapped, you don't want to feel closed in and hitting your legs on your desks and stuff. It was a pretty good feat to make it all fit in there without being in each others way. But it worked out.]

31. "I wanted the design to comply to code pertaining to handicap accessibility and so it had space for moving around."

30. "[If 33] I designed a three-foot space in the traffic area."



I: This is the second time you mentioned handicap accessibility. Why are you thinking in terms of handicap accessibility?

S: You just have to. If you don't . . . [**(32)**if you do any kind of commercial or industrial, or any type of construction, or design, **(33)**it has to be there.] Even in going to the bathrooms here, there are two regular stalls and a handicap stall . . . a wider stall with hand railings and everything. It just has to be considered. You have to have handicap runways for a wheelchair to be able to move in and out, no steps. It just has to be considered.

32. "We do commercial, industrial, and other types of architectural design work."

33. "[If 32] we have to design in handicap accessibility."



I: Okay. In going back to the furniture and the size of the room, did you think about what furniture should go in or the size of the room first?

S: [**(34)**I started laying out the furniture first to see . . . because **(35)**I thought what the person might want. Then I threw it all, put it all in the room, and then I began arranging it to see if it would work out. And fortunately, it worked out pretty good.]

I: Why did you think in terms of what the person needed before you thought of space?

S: I . . . if it was my position, I'd say, "Well, this is what I want. Can you fit it in there?" And then whatever . . . if it wouldn't fit, then I'd have an idea of what I'd have to start taking out.

35. "I thought about what furniture the person I was designing the office for might want."

34. "[If 35] I started laying out the furniture without first considering how much furniture an office of that size would accommodate."

35
▲
|
▼
34

I: So, it sounds like the way you thought through the project is, you made an assumption about the client, who the client is, then you thought in terms of what that client would want in the room. And then you manipulated the furniture to fit the constraints of the room.

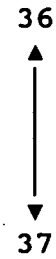
S: Right. I did have a three-foot by five-foot desk for the computer, and the printer. And that was going to make . . . six inches is six inches . . . [**(36)**if you have a two-foot-six walk area, you need six inches. So that's why I cut it down to two-six. And that gave me an extra six inches, which made one walk area big enough. **(37)**So I did have to make a desk smaller.]

I: Is that the only piece of furniture you had to replace once you got it in the room, or were there others that you had to resize?

S: I had to move . . . I didn't have to replace any, but I did have to move some stuff. I had the credenza right next to the person. His desk is in this orientation, facing the door. The credenza was to his left, and the walk space coming out next to the credenza was too tight. So I moved the two-drawer lateral file from the wall the door was on to the wall to his left, then move the credenza to that wall and it cleared it up.

36. "You have to have a three foot walk area in an office."

37. "[If 36] I had to redesign some of the furniture to accommodate the walk area."



I: You had the credenza to his left first and the file on the wall with the door originally. Why did you have that arrangement first rather than the other way around?

S: So the credenza would be accessible to him. I figured he'd want to be closer to it first. I've never had a credenza, so I wouldn't . . . I've never been that high up, but I assumed that he might want that closer to him . . . he or she, I must say . . .

I: Let me go through this again. You said it took you two or three hours from the time you started to solve the problem to the time you actually finished the design. First thing you did was to lay out the basic outline of the walls, and you used the twelve by fourteen measurements as inside dimensions. [**(6)**You used a particular kind of architectural software that you have in-house, and that's the reason you used it, because that's what's available.

S: **(38)**We also think it's the best.

I: **(39)**So you had done some evaluation some time ago before you guys even decided on that?

S: Yes.]

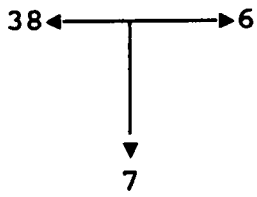
39. "We did an evaluation of design software programs."

38. "[If 39] we decided the program we decided to use as a standard is the best."



6. "[If 38] A choice of design programs was not available."

7. "[If 38+6] I used the program that is the company standard."



I: The entrance door is a three-foot door six inches off of one wall, the reason it's a three-foot door is for handicap accessibility, and that's what code calls for for accessibility. The reason you have it six inches off of one wall rather than placed anywhere else on that wall is that way you'll have more wall space. You have windows going along the back of the wall -- the windows are three feet wide and you have four windows for a total of twelve feet. They're set two to three feet off the floor. The reason you have them two to three feet off the floor is so you can push a desk or other piece of furniture up against that wall. Why do you have windows in the first place?

S: I did a lot of house design before I came here, [**(40)**and the reason you had windows in every room is because **(41)**there's fire code for that. It might be the same here, but the windows don't open, so I don't know if it would do any good or not. It might be fire code, but **(42)**the reason I did it is for light inside the office. **(43)**It's good to have regular sunlight during the day. You don't need to be dependent on fluorescent lights, or whatever you have in the office. It nice to be able to see outside during the day occasionally.]

41. "A fire code that requires certain design features exists."

40. "[If 41] you must design windows in every room."

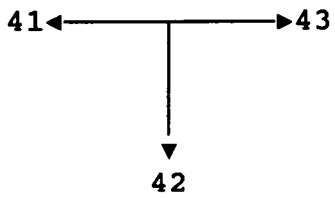


43. "Natural light and the ability to look outside in an office is preferred."

42. "[If 43] I designed the office to have windows."



42. "[If 41+43] I designed the office to have windows."



I: After you designed the windows along the back wall, you populated the office with furniture. It sounds like once you get the door and windows designed into the office, structurally that's all you have to do -- put the walls up, the windows, and the door -- for an office this size.

S: Um, hmm.

I: Then you populated the office with furniture. You told me the reason . . . the way you thought through that part of the project, you assumed that it was going to be for a manager. The next step you used to determine the furniture, was you thought what furniture that manager would use the most and want. Then you thought in terms of sizing the furniture and spacing it. In fact, you had to cut down on the size of one piece of furniture, the desk with the computer on it, from three-foot by foot to two-six by five. The reason you have an executive desk is it's a good size, it's nice looking, the reason you have an executive high-back chair is that it's a nice chair. The reason you have the credenza and the two-drawer lateral file is for storage. You assume the manager would want a lot of storage space for materials. You have a trash can. You have a phone. The computer and printer . . . you tell me managers more and more, at least in this business -- and I'm assuming it's for this business . . .

S: Um, hmm.

I: . . . are using computers and printers more and more. You put a plant in for aesthetics, a guest chair for visitors. We talked a little about why you needed a three-

foot space for traffic areas, and it's for handicap accessibility and for compliance to code. What did you do after you finished populating the office with furniture?

S: After I did that, I used the software package to project the office into a 3D office . . . to make it three dimensions.

I: So you used the software package to project 3D. What did you do then?

S: That was it. I looked at it. I shaded it and looked at it.

Subject 2
Problem 2
Interview 2
ANALYSIS

I: What would the first thing that you'd do be?

S: [(2)The first thing I'd do is just lay out the walls using the dimensions as inside dimensions.

I: Why would you lay out the walls first?

S: (1)That's the first thing you do to know what you're going to do on the inside.]

1. "I want to get an idea of how to design the inside space of the office."

2. "[If 1] the first thing I'd do is lay out the walls using inside dimensions."



I: What would you do to lay out the walls . . . in terms of the software program that you're using?

S: [(3)The software we use lays out the walls automatically. All you've got to do . . . if you have four walls, (4)you pick this command that's called "place room: . . . or whatever . . . and it places one whole . . . four walls. You give it the first digitizing point and key in the dimensions and it'll lay it in for you.]

3. "I want to software program to lay out four walls in the drawing automatically."

4. "[If 3] I use the 'place room' command."



I: Okay. The first thing you do is lay out the walls using a software program. You do that by putting a point on the screen with the digitizer, and then the computer program will automatically lay out the walls according to the dimensions you lay into it?

S: Double-line walls.

I: Okay. What would you do next?

S: Put in a door.

I: Why would you put in the door as the second step?

S: It's not anything in particular, step-wise; it's just preference-wise.

I: [Anything special about the placement of the door, the size of the door?

S: Yeah . . . (6)try to put it close to one wall . . . (5)so you can have more wall space to lay out furniture.]

5. "I want to design the office to maximize wall space for placing furniture."

6. "[If 6] I place the door in the design close to a corner."



I: [How about the size of the door?

S: (8)Three foot.

I: Why would you use a three foot door?

S: (7)'cause that's the minimum size on an office door for code . . . handicap accessibility.]

7. "I want to satisfy code in my design."

8. "[If 7] I design the door to be three feet wide."



I: So, you'd lay in the walls, and you'd put in the door . . . what would you do after that?

S: [Go ahead and lay out the windows. Assuming that the back wall is an outside wall.

I: So you'd assume that the back wall is an outside or exterior wall. Any particular reason why this step is coming when it's coming?

S: Nah.

I: Preference?

S: Um, hmm.

I: What would be . . . how would you lay out the windows?

S: (9)I would have made the back wall, probably the twelve foot dimension. (10)Have three . . . or four, rather, three foot windows . . . modular purposes.]

9. "I would design the back wall to be a twelve foot wall."

10. "[If 9] I can design the back wall to have four-three foot windows."



I: Okay. And how do you do that? How do you lay out the windows using the software program?

S: [(12)It has a "window" command. You'd actually go in and put the data point where you want your window and your size . . . actually, it's database driven, and it has all the sizes. And you can either select the default size that it has at the current time or you can go into the database and select a different size window and (11)it will put it in for you.]

11. "I want the software to generate windows automatically."

12. "[If 11] I use the 'window' command."



I: Okay. What would you do after you've laid-in the windows?

S: Then you start laying out furniture.

I: How do you do that?

S: [The way I did it was . . . actually, it probably was . . . it's not necessarily the wrong way to do it, but it's the way we've been laying out offices over at ours. (13)Everybody decides what they want, (14)and then we try to see if it works, and then if does, fine. (15)And if it doesn't, (16)start taking furniture out. So I just threw in a bunch of furniture I assumed that the person would want, then start trying to arrange it to where you could get around in the office.]

13. "I place office furniture in the drawing and determine it fits."

14. "[If 13] I arrange the furniture to fit the office space."



15. "I place office furniture in the drawing and determine it doesn't fit."

16. "[If 15] I remove furniture from the design and arrange remaining furniture in the drawing."



I: So, the type of furniture came first before the sizing, and that type of thing.

S: Um, hmm.

I: How did you decide what type of furniture? What assumptions did you make about the office and what kind of furniture to lay out?

S: I just . . . just for . . . no particular reason. I just decided . . . thought it might be a manager's office.

I: So, an assumption you're making is that it's the manager's . . . a manager's office. How do you lay out furniture . . . using the software program?

S: [(18)It has a . . . actually there's another . . . software program we have other than "Project Architect," which is called "Project Layout." (17)And it does inside office design -- furniture, and . . . steel case partitions, and all different kinds of furniture . . . chairs and desks and partitions . . . even small things, such as phones . . . like that.]

17. "I want to use a software program to lay out office furniture in the drawing."

18. "[If 17] I use the 'Project Layout' software program."



I: Does "Office Layout" (sic) an "Intergraph" add-on, or is it stand-alone?

S: It's an "Intergraph" package.

I: Okay. What furniture did you choose for the office?

S: [(20)Chose a three foot by six foot, two-drawer desk . . . right, left . . . actually, I guess it would be a four-drawer desk, 'cause it had drawers on each side.

I: Okay. Why did you choose that type of desk?

S: (19)Just for the extra room . . . extra storage.]

19. "I want to place a desk with extra storage space into the design."

20. "[If 19] I use a three foot by six foot, two drawer desk in the design."



I: Okay. And, what else . . . in terms of furniture? What other pieces?

S: [(22)Credenza.

I: Okay. Why did you choose a credenza?

S: (21)That's for looks and storage.]

21. "I want to place a piece of furniture in the design that can be used for storage and is attractive."

22. "[If 21] I place a credenza in the design."



I: What else?

S: [(25)I'd have a two-drawer lateral file . . . for files.

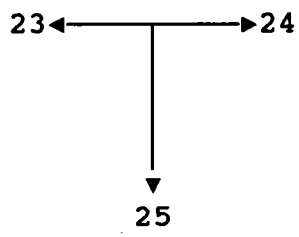
I: Why did you choose two-drawer lateral file as opposed to any other type of file?

S: (23)They're . . . well the two-drawer, if you buy furniture that's close to the same brand and looks the same, it could almost be modular. (24)You can move it up next to your desk and it would be about the same height and it will look good if you have a space problem. You could slide it up next to your desk and put stuff on it, then you'd have your lateral files to put you folders and stuff in.]

23. "I want furniture to be the same brand so that it looks the same."

24. "I want a file cabinet that can be placed next to the desk."

25. "[If 23+24] I place a two-drawer lateral file in the drawing."



I: Okay. What other furniture? Anything else?

S: [(27)I'd have a table -- a five foot by two-and-a-half foot table to put a computer and printer on.

I: Okay. Why did you have that table?

S: (26)Because, hopefully, now-a-days the way things are going, everyone just about has a computer sitting on their desk . . . even the upper management are starting to use them a lot more. So, it would be nice to have an area to put one. Plenty of room, because, you get a good size computer and a printer, you've taken up four foot, five foot area.]

26. "I want furniture to accommodate a good size computer and printer."

27."[If 26] I place a five foot by two foot table in the design."



I: What else? Anything else?

S: [(29)I think I've just put a telephone it for the look . . . the three dimensional look. (31)And an executive chair.

I: What do you mean you'd put a phone in for the looks?

S: (28)Well, you know, just something to add to the three dimensional look whenever you bring it up into three-D.

I: Okay. Is that something that would be used by a manager, though? Is that why there's a phone in the first place?

S: Oh, yes! Definitely.

I: And the executive chair -- what . . . why did you put an executive chair?

S: (30)Just a nice chair for . . . high back chair for that person.]

28. "I want to add features to the drawing to add to the three dimensional look of the drawing."

29. "[If 28] I place a telephone into the drawing."

28



29

I: What did you do after you placed the furniture?

S: Just added a few other things for . . . actually, put a guest chair in, because you need one. Like, right now, I'm sitting in your guest chair. And a plant for looks, aesthetics.

I: Okay . . . plant for aesthetics . . .

S: After you've laid-in all the furniture, then you can project-up the walls, doors, and windows into three-D . . . the completed three-D look.

I: Okay. Let me summarize where we've gone so far. In doing this problem the first thing you'd do is lay-out the walls using the inside dimensions. Put in the door, and the door would be close to one wall so you'd have more continuous wall space. It would be a three foot wide door because of handicap accessibility required by the code. You're assuming that there's an outside that you place windows in. That one of the walls . . . that the wall that you'd place the windows in is one of the twelve-foot walls so you could put three, four foot windows. You laid out the furniture, and you determined the furniture based on what you thought would be needed prior to figuring out sizing of the office. You're assuming it would be a manager's office, so you put a three foot by six foot two-drawer desk, which actually has four drawers -- two on each side. You want a desk like that because it offers a lot of storage capacity. You put in a credenza for looks and storage. You have a two-drawer lateral file that you can butt-up against the desk and it would fit in a modular way with other furniture. You'd have a five by two-and-a-half foot table for a computer and printer. You're assuming that the manager would have need for a printer. You'd add a phone for obvious communication reasons. An executive chair. You'd have a guest chair so that when you have a meeting, the guest would have a place to sit. You'd have a plant for aesthetics. After you put the furniture in the room, then you'd project the drawing into three-D view. Why would you do that?

S: Just to go and you can see what's going on in your drawing more if your manager wants to come up and look what his office is going to look like. If you're looking down on a two-D plan, you can kind of see what's going on. But you shoot that thing up in three-D and maybe even shade it for 'em, and get down inside the office and move 'em around in there, they can really see what it's going to look like.

I: What is shading?

S: That's when you take a "wire frame" and paint it. It paints all the different desks and everything . . . like you saw <referring to other drawings the interviewer looked at before the interview began>. All those were shaded views, actually. Shaded with patterns. You can do just a color shade or you can do a shade with patterns . . . to show like wood grain on a desk, and stuff like that.

I: Okay. So, then, after you look at the drawing in three-D view, what's the next step?

S: That's it. Unless you want to go to video with it.

I: Thank you very much.

APPENDIX E: RULES OBTAINED FROM ANALYZED TRANSCRIPTS

APPENDIX E: RULES OBTAINED FROM ANALYZED TRANSCRIPTS

The rules on the following pages use the coding scheme illustrated on page 44.

Subject 1
Problem 1
Interview 1
RULES

RULE 1.1.1.1

IF: there are similarities of various drawing styles
THEN: they are grouped together accordingly

RULE 1.1.1.2

IF: mechanical and electrical drawings are done at a scale of one-to-one
THEN: the borders are increased proportionately and there is no need to rescale drawings to fit together

RULE 1.1.1.3

IF: civil, structural, and architectural drawings have various scale details
THEN: the proportion of the borders might have to be scaled-up to match the proportion of the drawing

RULE 1.1.1.4

IF: there are only five drawings
THEN: only one seed file is necessary

RULE 1.1.1.5

IF: a border is attached to the seed file
THEN: the border is drawn automatically with the drawing

RULE 1.1.1.6

IF: the drawing is rendered for a particular client organization
THEN: the client organization's border is used

RULE 1.1.1.7

IF: civil/structural and architectural drawings are rendered at a scale of 1/2" to a foot
THEN: the border is scaled at twelve-to-one

RULE 1.1.1.8

IF: the drawings require a lot of text notes
THEN: the default level should be set to 46

RULE 1.1.1.9

IF: mechanical, electrical, and cover sheet drawings are rendered at a scale of one-to-one
THEN: the text sizing should be set at one-eighth of an inch

RULE 1.1.1.10

IF: the grid size used is one-half text size
AND: the text size is one-eighth of an inch
THEN: the grid size is one-sixteenth of an inch

RULE 1.1.1.11

IF: standard line weights and codes are used
THEN: line code should be set to "one" for text and "zero" for new lines

RULE 1.1.1.12

IF: no guidelines are given for dimensioning attributes
THEN: set dimensions according to personal preference

RULE 1.1.1.13

IF: it is determined that title headers and details are needed
THEN: the general cell library should be used

RULE 1.1.1.14

IF: the settings of the seed file are saved
THEN: the file maintains the attribute definitions

RULE 1.1.1.15

IF: typing 'Control-F' is faster than typing 'file' or using the mouse to save settings
THEN: type 'Control-F' to save the settings

Subject 1
Problem 1
Interview 2
RULES

RULE 1.1.2.1

IF: the client organization is determined
THEN: the border to be attached can be determined

RULE 1.1.2.2

IF: the size of the job is determined
THEN: The number of seed files to be created for each scale factor can be determined

RULE 1.1.2.3

IF: different scale factors are determined
THEN: borders can be set to match each scale factor

RULE 1.1.2.4

IF: different number of seed files per scale factor is determined
THEN parameters can be set up accordingly

RULE 1.1.2.5

IF: the client's procedures are reviewed
THEN: client's requirements can be followed

RULE 1.1.2.6

IF: the client's standards are available
THEN: they are used to develop dimension attributes

RULE 1.1.2.7

IF: the client's standards are unavailable
THEN: use company standards to develop dimension attributes

RULE 1.1.2.8

IF: text attributes are to be set
THEN: key in appropriate short commands

RULE 1.1.2.9

IF: text size is to be determined
THEN: use scale factor to determined text size

RULE 1.1.2.10

IF: the drawing is to be three-dimensional
THEN: set view attributes

RULE 1.1.2.11

IF: view attributes are to be set
THEN: turn multiple views feature on

RULE 1.1.2.12

IF: views are to be defined
THEN: activate the view number and assign a defined parameter to it

RULE 1.1.2.13

IF: parameters are to be saved
THEN: type Control-F or "file," or pull it off the dialogue box

RULE 1.1.2.14

IF: the scale of the drawing is to be determined
THEN: determine the size of the object to be drawn

Subject 2
Problem 1
Interview 1
RULES

RULE 2.1.1.1

IF: the project requires five drawings
THEN: use only one seed file

RULE 2.1.1.2

IF: the grid lock is turn on
THEN: lines can be drawn to grid points

RULE 2.1.1.3

IF: the line is to snap to the mid-point
THEN: the snap feature should be set to "two"

RULE 2.1.1.4

IF: features are set to the way our office desires
THEN: we set the standards for the company

RULE 2.1.1.5

IF: locks are one of the first things set up
THEN: then you can be sure that step has been taken care of

RULE 2.1.1.6

IF: it is rare that a drawing requires increments smaller than an eighth-of-an-inch
THEN: grid spacing is set at an eighth-of-an-inch

RULE 2.1.1.7

IF: scale is set up according to the border
THEN: a one-to-one scale is set up in the seed file

RULE 2.1.1.8

IF: a fast computer is used for drawings
THEN: resolution can be set to "high"

RULE 2.1.1.9

IF: text nodes are not to be plotted in the drawing
THEN: turn off the text node feature in the seed file

RULE 2.1.1.10

IF: text is to be placed at certain points in the drawing
THEN: turn on the data fields feature in the seed file

RULE 2.1.1.11

IF: data fields are to be viewed only in certain views
THEN: set up drawing so to be able to switch between views that have data fields set to on or off

RULE 2.1.1.12

IF: the data field feature is set to off in a certain view
THEN: data fields will not be visible in that view

RULE 2.1.1.13

IF: underbars are to be visible only in some views
THEN: turn off underbars in view five

RULE 2.1.1.14

IF: drawing is set up so operator can open desired views
THEN: operator can open any view desired

RULE 2.1.1.15

IF: the computer used for drawing is fast
THEN: dimensions can be turned on in both views

RULE 2.1.1.16

IF: bringing in first floor plan as an underlay to the second floor plan is desired
THEN: set up the reference clip feature in the seed file

RULE 2.1.1.17

IF: the reference clip file is set up
THEN: multiple drawings do not have to be updated

RULE 2.1.1.18

IF: seeing reference clip is not desired
THEN: leave reference clip feature turned off

RULE 2.1.1.19

IF: office standard for dimension terminators is used
THEN: dimension terminators are filled-in arrows

RULE 2.1.1.20

IF: dimensions are placed according to office standards
THEN: dimensions are placed above the line

RULE 2.1.1.21

IF: standard drafting procedures are used to set weight of dimension lines to one
THEN: text will stand out from lines

Subject 2
Problem 1
Interview 2
RULES

RULE 2.1.2.1

IF: the client has CAD standards
THEN: the client's standards are used

RULE 2.1.2.2

IF: the client does not have CAD standards
THEN: use company CAD standards

RULE 2.1.2.3

IF: only five drawings are to be rendered
THEN: set up only one seed file

RULE 2.1.2.4

IF: drafting standards exist
THEN: use drafting standards when setting up the seed file

RULE 2.1.2.5

IF: standards do not exist for some drafting attributes
THEN: reach consensus with others in company to establish those standards

RULE 2.1.2.6

IF: the order of setting attributes in the seed file is inconsequential
THEN: set attributes according to preference

RULE 2.1.2.7

IF: the drafting job is one of many types
THEN: determine how many seed files are necessary

RULE 2.1.2.8

IF: if accurate lines are to be drawn automatically
THEN: set up the snap lock feature

RULE 2.1.2.9

IF: 90° lines are to be drawn from reference lines
THEN: set up the key point feature

RULE 2.1.2.10

IF: text node numbers are not to be plotted
THEN: turn off the text node feature

RULE 2.1.2.11

IF: grid is not to display on the screen
THEN: turn off the grid display feature

RULE 2.1.2.12

IF: curves are to display on the screen quickly
THEN: turn on the "fast curves" feature

RULE 2.1.2.13

IF: fonts are to display on the screen quickly
THEN: turn on the "fast fonts" feature

RULE 2.1.2.14

IF: the computer is fast
AND: the design file is not large
THEN: use the "slow curve" attribute

Subject 1
Problem 2
Interview 1
RULES

RULE 1.2.1.1

IF: a lot of light in the office is desired
THEN: place a lot of windows on one wall of the office design

RULE 1.2.1.2

IF: light is to be dispersed well and high on the walls
THEN: the overhead lighting should be designed to run perpendicular to the narrow dimension of the office

RULE 1.2.1.3

IF: reduction in the amount of shadow projected by lighting is to be reduced
THEN: design lighting to be oriented diagonally to furniture

RULE 1.2.1.4

IF: the door is to be opened with the left hand
THEN: the door handle should be placed in the design so that it is convenient to open the door with the left hand

RULE 1.2.1.5

IF: the office drawing involves one quick design
THEN: the design can be drawn into an already existing drawing

RULE 1.2.1.6

IF: furniture is placed in the drawing
THEN: furniture can be arranged in the drawing

RULE 1.2.1.7

IF: the drawing is to be rendered with elevations
THEN: the walls are to be modeled up by typing in the appropriate commands

RULE 1.2.1.8

IF: the drawing is to be developed so the edge, corners, and wall coloring are to be seen
THEN: render the drawing as a full hidden line drawing

Subject 1
Problem 2
Interview 2
RULES

RULE 1.2.2.1

IF: the walls have been placed in the drawing
THEN: the floor plan can be created

RULE 1.2.2.2

IF: the door in the design is to be wide
THEN: use a three-foot wide door in the design

RULE 1.2.2.3

IF: wall space is to be maximized
THEN: design the door to be in a corner opposite the wall with windows

RULE 1.2.2.4

IF: the cell library contains graphics of furniture already drawn
THEN: furniture for the office design can be chosen from the cell library

RULE 1.2.2.5

IF: the size of the office is determined
THEN: furniture can be placed in the design until the office is full

RULE 1.2.2.6

IF: the file cabinet is to take up minimal space in a vertical direction from the wall
THEN: use a lateral file cabinet in the design

RULE 1.2.2.7

IF: space for a lot of reference manuals is required
THEN: place a four-by-six-foot bookshelf in the design

RULE 1.2.2.8

IF: meetings are to be held in the office
THEN: place a guest chair in the office design

RULE 1.2.2.9

IF: the design arrangement of furniture is based on traffic flow and accessibility
THEN: move furniture in the office design to accommodate flow

Subject 2
Problem 2
Interview 1
RULES

RULE 2.2.1.1

IF: inside dimensions are used in design layout
THEN: measurements are easier to work with

RULE 2.2.1.2

IF: design work is done using a special architectural software program
THEN: the program lays in walls and doors and gives double line walls automatically

RULE 2.2.1.3

IF: design work is done using a special architectural software program
THEN: the program lays in walls and doors and gives double line walls automatically
AND: the drawing can be converted from 2-D to 3-D

RULE 2.2.1.4

IF: a standard design software program is chosen
AND: no other design software programs are available
THEN: the standard design software program will be used for design work

RULE 2.2.1.5

IF: doors are designed close to a corner
THEN: the design allows for more continuous wall space

RULE 2.2.1.6

IF: the designer assumes a wall is an outside wall
THEN: windows can be placed in the design

RULE 2.2.1.7

IF: windows are designed to be three feet wide
THEN: the designer can put four windows across in a twelve foot wall

RULE 2.2.1.8

IF: windows are designed to be two-and-a-half to three feet from the floor
THEN: desks can be slid up to walls under windows

RULE 2.2.1.9

IF: it is assumed that the office is being designed for a manager
THEN: there would be a need for storage space and file space, and a lateral file and credenza could provide that space

RULE 2.2.1.10

IF: a sizable, attractive desk is desired
THEN: a three-foot by six-foot executive desk is a good choice

RULE 2.2.1.11

IF: storage space in the desk is desired
THEN: a desk with drawers on both sides should be considered for the design

RULE 2.2.1.12

IF: a nice chair is desired
THEN: an executive high-back chair should be consider for the design

RULE 2.2.1.13

IF: the assumption is made that the manager is a forward-thinking manager
THEN: include a computer and computer furniture into the office design

RULE 2.2.1.14

IF: aesthetics are to be included into the design
THEN: consider placing a plant into the design

RULE 2.2.1.15

IF: the assumption is made that there will be visitors to the office
THEN: include a guest chair in the office design

RULE 2.2.1.16

IF: the design is to comply to code pertaining to handicap accessibility
THEN: a three-foot traffic area must be included in the office design

RULE 2.2.1.17

IF: the designer is involved in commercial, industrial, and other types of design work
THEN: handicap accessibility must be included in designs

RULE 2.2.1.18

IF: assumptions are made about the type of furniture the manager who will occupy the office might want
THEN: start by laying out the furniture without first considering office size

RULE 2.2.1.19

IF: code requires a three foot walk area in an office
THEN: you may have to redesign some furniture to accommodate the walk area

RULE 2.2.1.20

IF: an evaluation of design software programs is undertaken
THEN: the best program for design can be chosen as a standard

RULE 2.2.1.21

IF: fire code requires that certain design features shall exist, including windows in each room
AND: natural light and ability to look outside is preferred
THEN: design will include windows in each room

Subject 2
Problem 2
Interview 2
RULES

RULE 2.2.2.1

IF: an idea of how to design the inside space of the office is desired
THEN: lay out the walls using inside dimensions first

RULE 2.2.2.2

IF: the software program is to lay out four walls in the drawing automatically
THEN: use the "place room" command

RULE 2.2.2.3

IF: the office is to be designed to maximize wall space for placing furniture
THEN: place the door in the design close to one corner

RULE 2.2.2.4

IF: code is to be met
THEN: design the door to be three-feet wide

RULE 2.2.2.5

IF: the back wall is designed to be a twelve-foot wall
THEN: the design can include four three-foot windows in that wall

RULE 2.2.2.6

IF: the software is to generate windows automatically
THEN: use the "window" command

RULE 2.2.2.7

IF: it is determined that the office furniture placed in the drawing fits
THEN: the furniture in the drawing can be arranged to fit the office space

RULE 2.2.2.8

IF: it is determined that the office furniture placed in the drawing does not fit
THEN: remove specific pieces of furniture from the design and arrange remaining furniture

RULE 2.2.2.9

IF: a software program is to be used to lay out office furniture in the drawing
THEN: use "Project Layout" software program

RULE 2.2.2.10

IF: a desk with extra storage space is to be placed into the design
THEN: use a three-foot by six-foot, two drawer desk in the design

RULE 2.2.2.11

IF: a piece of furniture that can be used for storage and be attractive is to be placed in the design
THEN: place a credenza in the design

RULE 2.2.2.12

IF: all the furniture is to be the same brand so it looks the same
AND: a file cabinet is to be placed next to the desk
THEN: place a two-drawer lateral file in the drawing

RULE 2.2.2.13

IF: the furniture is to accommodate a good size computer and printer
THEN: place a five-foot by two-foot table in the design

RULE 2.2.2.14

IF: features are to be added to the drawing to obtain a three-dimensional look
THEN: place a telephone into the drawing

APPENDIX F: EXPERT SYSTEMS KNOWLEDGE BASES

APPENDIX F: EXPERT SYSTEMS KNOWLEDGE BASES

This appendix contains the subjects knowledge bases as they were coded into the expert system program shell.

Subject 1
Problem 1
KNOWLEDGE BASE

```
BKCOLOR = 3;
RUNTIME;
ACTIONS
COLOR = 15
DISPLAY "
                    PROCEDURE FOR SETTING UP SEED FILES"COLOR =
1
DISPLAY "
                          ************************************

   Thank you for agreeing to participate in this project.

  This expert system program will prompt you to answer a
series of questions.  Use the cursor keys to highlight your
choice to each question, then press the Enter key.

       When you've finished with your consultation, the
program will give a number of recommendations based on how
you've responded.

                          ************************************"

FIND The_strategies0
FIND The_strategies1
FIND The_strategies2
FIND The_strategies3
FIND The_strategies4
FIND The_strategies5
FIND The_strategies6
FIND The_strategies7
FIND The_strategies8
FIND The_strategies9
FIND The_strategies10
FIND The_strategies11
FIND The_strategies12
FIND The_strategies13
FIND The_strategies14

DISPLAY "

"COLOR = 15
DISPLAY"
```

```
Recommendations for developing seed files include:

"COLOR = 1
DISPLAY"

*_{The_strategies0} parameters_for_each_drawing

*_{The_strategies1} group_drawings

*_{The_strategies2} scale_the_border

*_{The_strategies3} one_seed_file_is_necessary

*_{The_strategies4} attach_border_to_seed_file

*_{The_strategies5} client_organization's_border

*_{The_strategies6} twelve-to-one

"COLOR = 15
DISPLAY "
                  (Press_the_Enter_key_to_continue)~"COLOR =
1
CLS

DISPLAY "

*_{The_strategies7} 46

*_{The_strategies8} size_text_at_one-eighth_inch

*_{The_strategies9} one-half_text_size

*_{The_strategies10}
set_line_code_to_1_for_text,_0_for_new_lines

*_{The_strategies11}
set_dimensions_according_to_personal_preference

*_{The_strategies12} the_general_cell_library

*_{The_strategies13} the_attribute_definitions

*_{The_strategies14} saved_fastest_by_typing_Control-F

"COLOR = 15
DISPLAY "
            ***** Thank you for participating in this
project *****
";

RULE SEED_FILE
```

```
IF    Seed_file=Yes
THEN  The_strategies0=it_will_not_be_necessary_to_reset;
ASK   Seed_file: "Do_you_intend_to_create_a_seed_file?";
CHOICES  Seed_file: Yes,No;

RULE NO_SEED_FILE
IF    Seed_file=No
THEN  The_strategies0=you_will_have_to_reset_parameters
     DISPLAY
"
                You will have to reset parameters for each
drawing

   ***** Thank you for participating in this project *****

                          Lou will now reset the program~";

RULE DRAWINGS_SIMILAR
IF     Similarities=Yes
THEN The_strategies1=you_should;
ASK Similarities: "Do_similarities_among_drawings_exist?";
CHOICES Similarities: Yes,No;

RULE DRAWINGS_NOT_SIMILAR
IF     Similarities=No
THEN The_strategies1=do_not;

RULE MECHANICAL
IF     Mechanical=mechanical
THEN The_strategies2=do_not;
ASK  mechanical:
"Is_the_drawing_mechanical,electrical_or_civil-architectural
?";
CHOICES mechanical:
mechanical,electrical,civil-architectural;

RULE ELECTRICAL
IF     Mechanical=electrical
THEN   The_strategies2=do_not;

RULE CIVIL-ARCHITECTURAL
IF     Mechanical=civil-architectural
THEN The_strategies1=you_should;

RULE ONE_SEED_FILE
IF     Only_five_drawings=Yes
THEN The_strategies3=only;
ASK Only_five_drawings:
"Do_a_majority_of_drawings_share_common_elements?";
CHOICES Only_five_drawings: Yes,No;

RULE MORE_THAN_ONE_FILE
```

```
IF      Only_five_drawings=No
THEN    The_strategies3=more_than;

RULE BORDER_ATTACHED
IF      Border_is_to_be_drawn_automatically=Yes
THEN    The_strategies4=you_should;
ASK     Border_is_to_be_drawn_automatically:
"Is_a_border_attached_to_the_seed_file?";
CHOICES Border_is_to_be_drawn_automatically: Yes,No;

RULE NO_BORDER_ATTACHED
IF      Border_is_to_be_drawn_automatically=No
THEN    The_strategies4=do_not;

RULE ORG_BORDER
IF      Drawing_is_for_particular_organization=Yes
THEN    The_strategies5=use;
ASK     Drawing_is_for_particular_organization:
"Is_the_drawing_for_a_particular_organization?";
CHOICES Drawing_is_for_particular_organization: Yes,No;

RULE NO_ORG_BORDER
IF      Drawing_is_for_particular_organization=No
THEN    The_strategies5=you_are_not_limited_to_a;

RULE BORDER_SCALE
IF      Scale_is_one-half_inch_equals_one_foot=Yes
THEN    The_strategies6=border_should_be_scaled_at;
ASK     Scale_is_one-half_inch_equals_one_foot:
"Is_scale_one-half_inch_equals_one_foot?";
CHOICES Scale_is_one-half_inch_equals_one_foot: Yes,No;

RULE NO_BORDER_SCALE
IF      Scale_is_one-half_inch_equals_one_foot=No
THEN    The_strategies6=appropriate_scale_may_be_other_than;

RULE DEFAULT_LEVEL
IF      Drawings_require_many_text_notes=Yes
THEN    The_strategies7=set_default_level_to;
ASK     Drawings_require_many_text_notes:
"Do_the_drawings_require_many_text_notes?";
CHOICES Drawings_require_many_text_notes: Yes,No;

RULE NO_DEFAULT_LEVEL
IF      Drawings_require_many_text_notes=No
THEN
The_strategies7=Consider_setting_default_at_other_than;

RULE TEXT_SIZING
IF      Drawings_are_one-to-one_scale=Yes
THEN    The_strategies8=it_is_appropriate_to;
ASK     Drawings_are_one-to-one_scale:
```

```
"Will_mechanical,_electrical,_and_cover_sheet_drawings_be_on
e-to-one_scale?";
CHOICES Drawings_are_one-to-one_scale: Yes,No;

RULE NO_TEXT_SIZING
IF      Drawings_are_one-to-one_scale=No
THEN    The_strategies8=do_not;

RULE GRID_SIZE
IF       Standard_drawing_methods=Yes
THEN     The_strategies9=grid_size_used_should_be;
ASK      Standard_drawing_methods:
"Will_you_use_standard_drawing_methods?";
CHOICES Standard_drawing_methods: Yes,No;

RULE NO_GRID_SIZE
IF        Standard_drawing_methods=No
THEN      The_strategies9=grid_size_used_may_be_other_than;

RULE LINE_CODE
IF      Standard_weights_and_codes_used=Yes
THEN    The_strategies10=it_is_appropriate_to;
ASK     Standard_weights_and_codes_used:
"Will_standard_line_weights_and_codes_be_used?";
CHOICES Standard_weights_and_codes_used: Yes,No;

RULE NO_LINE_CODE
IF      Standard_weights_and_codes_used=No
THEN    The_strategies10=you_may_not_need_to;

RULE DIMENSIONS
IF      Guidelines_given=Yes
THEN    The_strategies11=it_is_not_permissible_to;
ASK     Guidelines_given:
"Are_guidelines_for_dimensioning_attributes_given?";
CHOICES Guidelines_given: Yes,No;

RULE NO_DIMENSIONS
IF      Guidelines_given=No
THEN    The_strategies11=it_is_permissible_to;

RULE CELL_LIBRARY
IF      Title_headers_and_details_necessary=Yes
THEN    The_strategies12=use;
ASK     Title_headers_and_details_necessary:
"Will_title_headers_and_details_be_needed?";
CHOICES Title_headers_and_details_necessary: Yes,No;

RULE NO_CELL_LIBRARY
IF      Title_headers_and_details_necessary=No
THEN    The_strategies12=you_may_use_other_than;
```

```
RULE ATTRIBUTES
IF      Settings_are_saved=Yes
THEN    The_strategies13=the_file_will_maintain;
ASK     Settings_are_saved:
"Are_the_settings_of_the_seed_file_to_be_saved?";
CHOICES Settings_are_saved:Yes,No;

RULE NO_ATTRIBUTES
IF      Settings_are_saved=No
THEN    The_strategies13=the_file_will_not_maintain;

RULE CONTROLF
IF     Typing_Control-F=Typing_Control-F
THEN   The_strategies14=files_are;
ASK    Typing_Control-F: "How_will_you_save_files?";
CHOICES
Typing_Control-F:Typing_Control-F,Typing_FILE,Using_mouse;

RULE   FILE
IF     Typing_Control-F=Typing_FILE
THEN   The_strategies14=files_are;

RULE   MOUSE
IF     Typing_Control-F=Using_mouse
THEN   The_strategies14=files_are;
```

```
Subject 2
Problem 2
KNOWLEDGE BASE

BKCOLOR = 3;
RUNTIME;
ACTIONS
COLOR = 15
DISPLAY "
                        PROCEDURE FOR DESIGNING AN
OFFICE"COLOR = 1
DISPLAY "
                        ************************************

   Thank you for agreeing to participate in this project.

  This expert system program will prompt you to answer a
series of questions.  Use the cursor keys to highlight your
choice to each question, then press the Enter key.

       When you've finished with your consultation, the
program will give a number of recommendations based on how
you've responded.

                      ************************************"

FIND The_strategies1
FIND The_strategies2
FIND The_strategies2a
FIND The_strategies3
FIND The_strategies4
FIND The_strategies5
FIND The_strategies6
FIND The_strategies7
FIND The_strategies8
FIND The_strategies9
FIND The_strategies10
FIND The_strategies11
FIND The_strategies11a
FIND The_strategies12
FIND The_strategies13
FIND The_strategies14
FIND The_strategies15
FIND The_strategies16

DISPLAY "

"COLOR = 15
DISPLAY"
Recommendations for designing an office include:

"COLOR = 1
```

```
DISPLAY"

*_{The_strategies1}
inside_dimensions_to_make_measurements_easier.

*_{The_strategies2}
architectural_software_program_to_enable_2D_and_3D_views.

*_{The_strategies2a} the_best_architectural_
_design_software.

*_{The_strategies3} near_corners.

*_{The_strategies4} three_feet_wide_in_order_to_meet_code.

*_{The_strategies5} place_windows_in_design_of_wall.

*_{The_strategies6} width.

"COLOR = 15
DISPLAY "
                    (Press_the_Enter_key_to_continue)~"COLOR =
1
CLS

DISPLAY "

*_{The_strategies7} to_enable_desk_to_fit_under_windows.

*_{The_strategies8} to_include_a_lateral_file_and_credenza_
_for_storage_in_the_design.

*_{The_strategies9} desk_for_use_in_the_office.

*_{The_strategies10} drawers_on_each_side_for_storage.

*_{The_strategies11} choice_of_chair.

*_{The_strategies11a}
a_computer_and_computer_furniture_in_the_office_design.

*_{The_strategies12} to_increase_aesthetics_of_design.

"COLOR = 15
DISPLAY"
                    (Press_the_Enter_key_to_continue)~"COLOR =
1
CLS

DISPLAY "

*_{The_strategies13}
```

```
a_guest_chair_in_the_design_for_visitors.

*_{The_strategies14} consider_office_size_in_relation_to_
_furniture.

*_{The_strategies16} windows_in_each_room.


"COLOR = 15
DISPLAY"
                    (Press_the_Enter_key_to_continue)~"COLOR
= 1
CLS

DISPLAY"


"COLOR = 15
DISPLAY "
          ***** Thank you for participating in this
project *****
";

RULE IN_DIM
IF    Inside_dimensions=Yes
THEN  The_strategies1=Use;
ASK   Inside_dimensions:
"Do_you_desire_easier_measurements?";
CHOICES  Inside_dimensions: Yes,No;

RULE NO_IN_DIM
IF    Inside_dimensions=No
THEN  The_strategies1=Need_not_use;

RULE SPEC_PRO
IF     Spec_pro=Yes
THEN The_strategies2=Use;
ASK  Spec_pro: "Do_you_have_an_architectural_program?";
CHOICES Spec_pro: Yes,No;

RULE NO_SPEC_PRO
IF     Spec_pro=No
THEN   The_strategies2=Use_alternative_to;

RULE  EVAL
IF    Eval=Yes
THEN  The_strategies2a=An_evaluation_has_determined;
ASK   Eval:
"Has_an_evaluation_of_design_software_taken_place?";
CHOICES Eval:Yes,No;

RULE  NO_EVAL
```

```
IF    Eval=No
THEN
The_strategies2a=Evaluation_should_be_done_to_determine;

RULE DOORS_CORNER
IF     Doors_corner=Yes
THEN The_strategies3=Design_doors;
ASK  Doors_corner: "Do_you_desire_to_maximize_wall_space?";
CHOICES Doors_corner: Yes,No;

RULE NO_DOORS_CORNER
IF     Doors_corner=No
THEN The_strategies3=Doors_can_be_designed_far_from_or;

RULE THREE_FOOT_DOOR
IF     Three_foot_door=Yes
THEN   The_strategies4=Doors_&_traffic_areas_should_be;
ASK  Three_foot_door:
"Is_design_for_commercial_or_industrial_application?";
CHOICES Three_foot_door: Yes,No;

RULE NO_THREE_FOOT_DOOR
IF     Three_foot_door=No
THEN
The_strategies4=Doors_&_traffic_areas_can_be_less_than;

RULE OUTSIDE_WALL
IF     Outside_wall=Yes
THEN   The_strategies5=It_is_possible_to;
ASK    Outside_wall: "Is_wall_in_design_an_outside_wall?";
CHOICES Outside_wall: Yes,No;

RULE NO_OUTSIDE_WALL
IF     Outside_wall=No
THEN   The_strategies5=It_is_not_possible_to;

RULE 3FT_WINDOWS
IF     3FT_Windows=Yes
THEN   The_strategies6=Design_windows_to_be_three_foot;
ASK    3FT_Windows: "Outside
wall_is_12ft.--_Do_you_wish_to_cover_wall_with_windows?";
CHOICES 3FT_windows: Yes,No;

RULE NO_3FT_WINDOWS
IF     3FT_Windows=No
THEN   The_strategies6=Design_windows_to_be_any;

RULE WINDOW_FLOOR
IF     Window_floor=Yes
THEN   The_strategies7=Design_windows_to_be_3ft_from_floor;
ASK    Window_floor:
"Do_you_want_to_be_able_to_place_desk_under_windows?";
```

```
CHOICES Window_floor: Yes,No;

RULE NO_WINDOW_FLOOR
IF      Window_floor=No
THEN    The_strategies7=No_need_to_design_windows;

RULE MANAGER_OFFICE
IF      Manager_office=Yes
THEN    The_strategies8=There_is_need;
ASK     Manager_office:
"Is_the_office_being_designed_for_a_manager?";
CHOICES Manager_office: Yes,No;

RULE NO_MANAGER_OFFICE
IF      Manager_office=No
THEN    The_strategies8=There_may_or_may_not_be_the_need;

RULE SIZABLE_DESK
IF       Sizable_desk=Yes
THEN     The_strategies9=A_good_choice_is_a_3X6_executive;
ASK      Sizable_desk:
"Is_a_sizable_attractive_desk_desired?";
CHOICES Sizable_desk: Yes,No;

RULE NO_SIZABLE_DESK
IF        Sizable_desk=No
THEN
The_strategies9=A_decision_should_be_made_about_type_of;

RULE STORAGE
IF      Storage=Yes
THEN    The_strategies10=Desk_used_in_design_should_have;
ASK     Storage: "Is_storage_space_in_the_desk_desired?";
CHOICES Storage: Yes,No;

RULE NO_STORAGE
IF      Storage=No
THEN    The_strategies10=Desk_used_in_design_need_not_have;

RULE NICE_CHAIR
IF      Nice_chair=Yes
THEN
The_strategies11=An_executive_high-back_chair_is_a_good;
ASK     Nice_chair: "Is_a_nice_chair_desired?";
CHOICES Nice_chair: Yes,No;

RULE NO_NICE_CHAIR
IF      Nice_chair=No
THEN    The_strategies11=Need_to_determine_appropriate;

RULE FORWARD
IF      Forward=Yes
```

```
THEN    The_strategies11a=Include;
ASK     Forward:
"Is_the_manager_a_forward-thinking_manager?";
CHOICES Forward: Yes,No;

RULE NO_FORWARD
IF      Forward=No
THEN    The_strategies11a=You_may_not_need_to_include;

RULE AESTHETICS
IF      Aesthetics=Yes
THEN    The_strategies12=Consider_placing_a_plant;
ASK     Aesthetics:
"Are_aesthetics_an_important_part_of_the_design?";
CHOICES Aesthetics: Yes,No;

RULE NO_AESTHETICS
IF      Aesthetics=No
THEN    The_strategies12=No_need_to_add_items;

RULE VISITORS
IF      Visitors=Yes
THEN    The_strategies13=Include;
ASK     Visitors: "Will_there_be_visitors_to_the_office?";
CHOICES Visitors:Yes,No;

RULE NO_VISITORS
IF      Visitors=No
THEN    The_strategies13=No_need_to_include;

RULE FURNITURE
IF     Furniture=Yes
THEN   The_strategies14=Lay_out_furniture_before_you;
ASK    Furniture:
"Have_assumptions_about_desired_furniture_been_made?";
CHOICES Furniture:Yes,No;

RULE   NO_FURNITURE
IF     Furniture=No
THEN   The_strategies14=Before_placing_furniture_in_design;

RULE   FIRE_CODE
IF     Fire_code=Yes
OR     Nat_light=Yes
THEN   The_strategies16=Design_should_include;
ASK    Fire_code: "Is_design_required_to_meet_fire_code?";
ASK    Nat_light: "Do_you_want_natural_light?";
CHOICES Fire_code:Yes,No;
CHOICES Nat_light:Yes,No;

RULE   NO_FIRE_CODE
IF     Fire_code=No
```

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AND    Nat_light=No
THEN   The_strategies16=Design_need_not_include;
```

APPENDIX G: HYPERTEXT PROGRAMS

APPENDIX G: HYPERTEXT PROGRAMS

This appendix contains the hypertext programs that were designed using the subjects' knowledge bases.

Subject 1
Problem 1
HYPERTEXT PROGRAM

CONTENTS

1. Set parameters with a seed file
2. Drawing types are grouped together
3. Borders need not always be scaled
4. Proportions of borders for civil/structural and architectural drawings might have to be scaled-up
5. Only one seed file is necessary
6. The border is drawn automatically with the drawing
7. The client organization's border is used
8. The border is scaled at twelve-to-one for civil/structural and architectural drawings
9. The default level should be set to 46
10. The text sizing should be set to one-eighth of an inch for mechanical and electrical drawings and cover sheets
11. The grid size should be one-sixteenth of an inch
12. Line code should be set to "one" for text and "zero" for new lines
13. Dimensions should be set according to personal preference
14. The general cell library should be used
15. The file maintains the attribute definitions
16. Type 'Control-F' to save settings

RULE 1.1

IF a seed file is developed
THEN parameters need not be reset for each drawing

GO BACK TO CONTENTS

RULE 1.2

IF there are similarities of various drawing styles
THEN they are grouped together accordingly

GO BACK TO CONTENTS

RULE 1.3

IF the drawing is a mechanical or electrical drawing
THEN the border need not be scaled

GO BACK TO CONTENTS

RULE 1.4

IF civil, structural, and architectural drawings have various scale details
THEN the proportion of the borders might have to be scaled-up to match the proportion of the drawing

GO BACK TO CONTENTS

RULE 1.5

IF a majority of drawings are of one type
AND there are a limited number of drawings
THEN only one seed file is necessary

GO BACK TO CONTENTS

RULE 1.6

IF a border is attached to the seed file
THEN the border is drawn automatically with the drawing

GO BACK TO CONTENTS

RULE 1.7

IF the drawing is rendered for a particular client organization
THEN the client organization's border is used

GO BACK TO CONTENTS

RULE 1.8

IF civil/structural and architectural drawings are rendered at a scale of 1/2" to a foot
THEN the border is scaled at twelve-to-one

GO BACK TO CONTENTS

RULE 1.9

IF the drawings required a lot of text notes
THEN the default level should be set to 46

GO BACK TO CONTENTS

RULE 1.10

IF mechanical, electrical, and cover sheet drawings are rendered at a scale of one-to-one
THEN the text sizing should be set at one-eighth of an inch

GO BACK TO CONTENTS

RULE 1.11

IF standard drawing methods are used
THEN the grid size is one-half text size

GO BACK TO CONTENTS

RULE 1.12

IF standard line weights and codes are used
THEN line code should be set to "one" for text and "zero" for new lines

GO BACK TO CONTENTS

RULE 1.13

IF no guidelines are given for dimensioning attributes
THEN set dimensions according to personal preference

GO BACK TO CONTENTS

RULE 1.14

IF it is determined that title headers and details are needed
THEN the general cell library should be used

GO BACK TO CONTENTS

RULE 1.15

IF the settings of the seed file are saved
THEN the file maintains the attribute definitions

GO BACK TO CONTENTS

RULE 1.16

IF typing 'control-F' is faster than typing 'file' or using the mouse to save settings.
THEN type 'Control-F' to save the settings

GO BACK TO CONTENTS

Subject 2
Problem 2
HYPERTEXT PROGRAM

RULE 2.1

IF inside dimensions are used in design layout
THEN measurements are easier to work with

GO BACK TO CONTENTS

RULE 2.2

IF design work is done using a special architectural software program
THEN the program lays in walls and doors and gives double-line walls automatically
AND the drawing can be converted from 2-D to 3-D

GO BACK TO CONTENTS

RULE 2.3

IF a standard design software program is chosen
AND no other design software programs are available
THEN the standard design software program will be used for design work

GO BACK TO CONTENTS

RULE 2.4

IF doors are designed close to a corner
THEN the design allows for more continuous wall space

GO BACK TO CONTENTS

RULE 2.5

IF a three-foot wide door is used in the design
THEN the design will meet code specifications

GO BACK TO CONTENTS

RULE 2.6

IF the designer assumes a wall is an outside wall
THEN windows can be placed in the design

GO BACK TO CONTENTS

RULE 2.7

IF windows are designed to be three feet wide
THEN the designer can put four windows to cover a twelve-foot wall

GO BACK TO CONTENTS

RULE 2.8

IF windows are designed to be two-and-a-half to three feet from the floor
THEN desks can be slid up to walls under windows

GO BACK TO CONTENTS

RULE 2.9

IF it is assumed that the office is being designed for a manager
THEN there would be a need for storage space that a lateral file and credenza could provide

GO BACK TO CONTENTS

RULE 2.10

IF a sizable, attractive desk is desired
THEN a three-foot by six-foot executive desk is a good choice

GO BACK TO CONTENTS

RULE 2.11

IF storage space in the desk is desired
THEN a desk with drawers on both sides should be considered for the design

GO BACK TO CONTENTS

RULE 2.12

IF a nice chair is desired

THEN an executive high-back chair should be considered for the design

GO BACK TO CONTENTS

RULE 2.13

IF the assumption is made that the manager is a forward-thinking manager
THEN include a computer and computer furniture into the office design

GO BACK TO CONTENTS

RULE 2.14

IF aesthetics are to be included in the design
THEN consider placing a plant into the design

GO BACK TO CONTENTS

RULE 2.15

IF the assumption is made that there will be visitors to the office
THEN include a desk chair in the office design

GO BACK TO CONTENTS

RULE 2.16

IF the design is to comply to code pertaining to handicap accessibility
THEN a three-foot traffic area must be included in the office design

GO BACK TO CONTENTS

RULE 2-17

IF the designer is involved in commercial, industrial, and other types of design work
THEN handicap accessibility must be included in designs

GO BACK TO CONTENTS

RULE 2-18

IF assumptions are made about the type of furniture the manager who will occupy the office might want
THEN start by laying out the furniture without first considering office size

GO BACK TO CONTENTS

RULE 2-19

IF code requires a three-foot walk area in an office
THEN you may have to redesign some furniture to accommodate the walk area

GO BACK TO CONTENTS

RULE 2-20

IF an evaluation of design software programs is undertaken
THEN the best program for design can be chosen as a standard

GO BACK TO CONTENTS

RULE 2-21

IF fire code requires that certain design features shall exist, including windows in each room
AND natural light and ability to look outside is preferred
THEN design will include windows in each room

GO BACK TO CONTENTS

VITA

Louis Owen Rabinowitz was born in Johnstown, Pennsylvania on April 5, 1952. He attended elementary schools in the Westmont Hilltop School District and graduated from Westmont Hilltop Senior High School in June, 1970. The following September he entered Saint Francis College in Loretto, Pennsylvania and in May, 1974 received the degree of Bachelor of Science in Elementary Education. He entered West Georgia College in September, 1974 and in May, 1976 received the degree of Master of Arts in Psychology.

He is currently the President of Personnel Technology Group, Inc., an Oak Ridge, Tennessee firm that develops training and compensation systems for business and industry.