NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

A STUDY OF NOVICE SYSTEMS ANALYSTS'
PROBLEM SOLVING BEHAVIORS
USING PROTOCOL ANALYSIS

by

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September, 1992

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b. OFFICE SYMBOL (If applicable) 37	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS Program Element No. / Project No / Task No. / Work Unit Accession Number

11. TITLE (Include Security Classification)
A STUDY OF NOVICE SYSTEMS ANALYSTS' PROBLEM SOLVING BEHAVIORS USING PROTOCOL ANALYSIS

12. PERSONAL AUTHOR(S) Robert E. Baker Jr.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (year, month, day)	15. PAGE COUNT
Master's Thesis	From To	September, 1992	72

16. SUPPLEMENTARY NOTATION
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17. COSATI CODES			18. SUBJECT TERMS (continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUBGROUP	Novice Systems Analysts, Protocol Analysis, Expert-Novice Differences, Problem Solving Behaviors

19. ABSTRACT (continue on reverse if necessary and identify by block number)

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT [X] UNCLASSIFIED/UNLIMITED [ ] SAME AS REPORT [ ] DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL B. RAMESH	22b. TELEPHONE (Include Area code) (408)646-2439	22c. OFFICE SYMBOL AS/RA

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

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A Study of Novice Systems Analysts' Problem Solving Behaviors
Using Protocol Analysis

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
September, 1992

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ABSTRACT

The purpose of this research was to determine the problem solving behaviors of novice systems analysts during the design process. Using protocol analysis, this research found that novice analysts like their expert counterparts used an iterative problem solving process. However, unlike expert analysts, they exhibited a typical working behavior that tended to focus directly on the task at hand while overlooking larger but pertinent issues.

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I. INTRODUCTION

A. RESEARCH FOCUS

This research focuses on the problem solving behavior of novice systems analysts during the systems design process. In this study the term "novice" is used to describe someone who possesses sufficient knowledge to function in a specific domain, but has limited practical experience in that domain. The findings will be compared to the problem solving behaviors of expert and novice financial analysts and expert systems analysts from the literature (Ramesh,1989; Vitalari, 1981). The outcome of this research identifies differences in problem solving techniques of experts and novices. Possible uses for the differences will be discussed.

B. SYSTEMS ANALYSTS

What does a systems analyst do? A systems analyst may be compared to a language interpreter. The systems analyst functions as a mediator between the customer and the computer programmers and operators to facilitate effective communication. The systems analyst bridges the gap between the language, needs, and culture of the customer and those of the computer specialists (both hardware and software). Thus the systems analyst's is required to be able to interface with the customer to understand separate business functions and their intertwining relationships, and then to be able to represent this information in a format understandable to computer specialists for developing the system. The systems analyst is a designer, technician and artist all in one.

1. Growing Demand

In today's competitive environment, information has become a strategic resource. Its prudent use, in many cases is essential to the very survival of organizations. This information requirement has exponentially increased the demand for systems capable of expeditiously representing data in formats compatible with an organizations' needs. As hardware becomes more capable and users become more aware of what computers can do for them, their desire for newer and more capable systems increases. This results in the already voluminous backlog of desired products.

2. Difficulties Meeting Demand

The demand for qualified and experienced systems analysts continues to grow. Currently this growing demand is hindered by the decreasing population from which new analysts can join the work force, and the extensive on-the-job experience currently required for a novice to progress to the level of expert systems analyst. The above problem is exacerbated by the fact that the size of the population under instruction required to maintain parity is directly proportional to the duration of the instruction (Chi, Glasser and Farr, 1988).

3. Solution

Many years of training and experience are required for a novice systems analyst to become an expert in his field. If properly addressed, the duration of this transition might be reduced. One suggested solution could be to identify the problem solving differences exhibited between expert and novice systems analysts during the design process. If these differences could then be incorporated into an educational and training process of systems analysts, the duration of the transition from novice to expert systems analyst could possibly be decreased. The decrease in the duration of the transition time would increase the supply of expert systems analysts, thereby lessening the demand.

C. THESIS ORGANIZATION

This thesis consists of five chapters. It is arranged to allow the reader to follow the development of the research from initial problem identification in Chapter I to proposed solutions in Chapter V.

Chapter II provides a detailed description of the research design. Chapter III discusses the findings and contains a list of specific behaviors exhibited by novice systems analysts during this study. In Chapter IV the results of comparative studies between expert and novice systems analysts and expert/novice financial analysts and novice systems analysts are provided. Chapter V, the conclusion suggests possible uses for the expert-novice differences identified during the comparative study.

II. RESEARCH DESIGN

A. RESEARCH OBJECTIVE

This study views and analyzes the problem solving behavior of novice systems analysts during a task performance. The results obtained will be compared with the problem solving behaviors of expert systems analysts and expert/novice financial analysts, as identified in other studies. These comparisons will identify if differences exist in the problem solving behavior of novice-novice or novice-expert analysts. The goal of this study is to identify these differences.

The basis of this research is that the cognitive processes of individuals may be identified by analysis of task performance (Ericsson and Simon, 1984). As the functionality of the cognitive processes is similar to that of an information processing system, a process model of the cognitive processes may be developed and analyzed (Vitalari, 1981).

B. RESEARCH METHOD

The methodology used in this study for capturing and analyzing the problem solving behavior of novice systems analysts during task performance is protocol analysis. A detailed description of this technique is provided in Appendix A.

C. SUBJECT SELECTION

The first task when selecting the subjects for the study was to identify a specific population from which to choose the subjects. It was determined that the subject population should possess two specific attributes. The first was exposure to the theoretical procedures used by systems analysts during the systems design process. The second was minimal practical experience as systems analysts.

The population identified as possessing these two required attributes was fifth quarter students in the Computer Systems Management (CSM) Curriculum at the Naval Postgraduate School, Monterey, CA. The first attribute requiring exposure to theoretical procedures used by systems analysts during the design process was satisfied by the subjects' classroom exposure in the CSM curriculum. While in this curriculum, the entire population received classroom instructions on systems design, database design and management, decision support and expert systems, programming, hardware and operating systems design, economic and financial considerations and managerial issues. In addition, as part of the instruction, the entire population participated in group and individual projects that required practical application of classroom theory.

Volunteers were solicited. Eight students were selected to participate as subjects. They were all military officers. The group consisted of one Marine Corps officer and seven

Naval officers. Three of the subjects were Navy Lieutenant Commanders and the other five were Navy Lieutenants or their Marine Corps equivalent.

Their undergraduate degrees were diverse in nature ranging from Computer Science to English. Only one subject had ever taken more than two computer related (specifically programming) courses prior to commencing their studies at the Naval Postgraduate School, Monterey, CA.

Prior to attending the Naval Postgraduate School only one of the subjects had ever been involved with a systems development project in any capacity. That exposure consisted of functioning as a customer acceptance testing representative for the Navy on a systems development project. The subjects' minimal experience satisfied the second essential attribute.

Though not a required attribute, it was interesting to note that all subjects, when asked, responded that they had never to their knowledge participated in a study that utilized Protocol Analysis. Each indicated that this was the first experience where they had been asked to think-aloud as they performed a task.

D. TASK REVIEW

The study was limited to the task of developing functional specifications during the Information Requirements Determination (IRD) phase of the systems development life cycle. The IRD phase may be considered to be the most important segment of any systems development project. However, its importance is often overlooked or misunderstood as senior management considers the IRD phase to be an activity leading to an intangible product. Therefore sufficient time and resources are not allocated to the IRD. Budgetary constraints and the desire to have products marketed frequently lead to decisions to start implementation and work out the details or problems later. However, neglecting the IRD phase can prove to be disastrous. The literature is full of examples of systems development projects that were terminated or experienced significant delays and cost overruns when inadequate resources were placed into the IRD phase. The following are just a few examples:

- Army Civilian Personnel System experienced a cost increase from the original 65 million projected to 96 million dollars (GAO, 1989).
- Defense Logistics Agency's Defense Logistic Service Center experienced a cost increase from the original 123 million projected to 177 million dollars (GAO, 1989).
- Air Force Contract Data Management System experienced a cost increase from the original 34 million projected to 74 million dollars (GAO, 1989).
- Navy's Standard Automated Financial System experienced a cost increase from the original 33 million projected to 479 million dollars before the project was terminated (GAO, 1989).

Therefore, the IRD phase should be considered to be crucial for successful systems development. The responsibility of convincing management to provide sufficient time and resources for the IRD phase lies with the systems analyst. Furthermore, it is also the systems analyst's responsibility to ensure that developmental efforts during the IRD phase are competently and professionally conducted.

Each subject was given the same task to perform. The task involved a case study (Appendix B) of a utility company's customer order processing system. This case study had been successfully used several times before in settings involving the use of protocol analysis for identifying problem solving behavior (Ramesh, 1989).

The task was to design a customer order processing system that utilized a centralized telephone answering service center, connected by an online computer to a large number of field stations that were responsible for providing services to the customers in their respective geographical areas of responsibility. The objective of the system was to provide quick response to customer requests for activities such as starting a service, stopping a service, switching a service, repairing appliances, setting up a location for services, removing services from a location and responding to power outages. The system should also provide real-time status of customer requests. The status would be used by utility representatives at the centralized telephone answering service center for answering customer inquiries about customer requests.

Included with the task was a description of the utility company's customer order processing system that was developed based on information obtained by a large systems consulting firm during an actual systems development project(Ramesh, 1989).

E. EXPERIMENTAL PROCEDURES

The experimental sessions were scheduled to last approximately three hours. A separate session was scheduled for each subject. A facilitator was present for each entire session. The subjects could, if desired, take a short recess during the session.

Each subject was provided with a copy of this information. The subjects were advised that the facilitator possessed more detailed information about the required system than that which was provided in their handout and could answer questions for clarification purposes. This option was only available prior to the initiation of the design process.

1. Subject Briefing

The first action during each session was to brief the subject about what he would be doing during the session and how the data he was going to provide would be used. The subject was then assured that the objective of the research was to understand rather than evaluate the problem solving behavior.

2. Think-Aloud Familiarization

The subject was then asked to participate in a structured exercise to provide him with the opportunity to become comfortable thinking-aloud while performing a task. First he was given instructions designed to have him talk-aloud while performing a task. Next, he was provided with a task (math and word problem) to perform. If additional practice was needed after the first task, subsequent tasks (word problems) were provided until the subject was comfortable with the technique.

3. Problem Introduction

The subject was then given a handout with a description of the system to be designed. He was informed that the facilitator had additional information and could clarify issues upon request. Then he was asked to read the handout and hold any questions until finished with the initial reading. At that point any questions would be answered. Any clarification desired would be provided. Once the question and answer session was over, the subject was informed that he could retain the handout during the actual design process, but that the facilitator would no longer answer questions. He was also advised that the facilitator would be present only to remind him to think-aloud. It was suggested that if he had additional questions he should make whatever assumptions were necessary to proceed with his assigned task.

4. Designing the System

Designing the system was the data gathering segment of the research. It was at this point that the tape recorder was turned on.

The facilitator was present during the entire two-hour session. However, as stated before, his only function was to remind the subjects to think-aloud.

5. Session Wrap-Up

The subject was asked to fill out the personal information sheet located in Appendix C at the end of the session. The information requested pertained to the subject's educational and professional background. It also included a question about whether they had ever participated in a study that required them to think-aloud while performing a task.

F. TRANSCRIPTION PROCESS

All transcribing was performed by the facilitator. Each subject's entire recorded protocol was transcribed verbatim. Punctuation of the protocols was based on the facilitator's knowledge of word combinations and interpretation of the subjects' verbal inflections while speaking.

G. ENCODING PROCESS

The results of the transcription were then used to develop a process model. Once the process model has been developed it can be used for determining the subjects problem solving behavior.

To develop a process model from which to analyze the subjects problem solving behavior, the weakest hypothesis required is that the subjects' cognitive process during task performance is similar to the operation of an information processing system (Ericsson and Simon, 1984). Data stored in the memory of a computer is in the form of electrical charges representing either ones or zeros. Without coding the ones and zeros are meaningless, but when encoded they represent data that is recognizable to a user. The human brain also represents stored data as electrical charges. For verbalization or output to take place the data in memory must first be encoded. By segmenting the verbalizations into their basic components and then coding them, one can use the coded data to develop a process model to be used for analysis.

Protocols are frequently analyzed using episode representation. This involves splitting the protocols into topic segments representing a single task, and then analyzing these segments to identify specific kinds of activities or episodes (Ramesh, 1989).

> Episodic memory contains information about individual experiences that a person has had plus generalized episodes or types of events. Generalized episodes ... are

created by comparing different episodes and calculating similarities between them... According to Kolodner (1983), "even if a novice and an expert have the same semantic knowledge ...the expert's experience would have allowed him to build up better episodic definitions... (Gilhooly, pp. 184-186,1986)

In this research, episode representation was used with a minor variation to analyze the protocols. Rather than splitting the protocols into topic segments representing a single task and then identifying the specific episodes within the task segments, the episodes were identified and categorized directly from the protocols without any preprocessing.

After the segmentation was completed each episode was analyzed independent of all other episodes and assigned a number representing the type of activity captured. This process was conducted twice. Results were compared and differences were reviewed before final assignment.

The numbering system for the types of episodic activity is provided in Table 1.

After all episodes were categorized, the numeric episode representations were separated from the protocols for comparison between the subjects.

Table 1: EPISODE TYPES KEY CODE

EPISODE TYPE	KEY CODE
Identification of Relevant Data	1
Identification of Problems	2
Identification of Relationships between Problems	3
Generation of Hypothesis	4
Confirmation of Hypothesis	5
Assessment of Problem Criticality	6
Goal Setting	7
Reviewing Previous Actions	8
Requesting Clarification from Customer	9
Making Assumptions	10
Disregarding Previous Actions	11
Reading fıom Case Write-Up	12
Intuitive Leap	13

III. RESEARCH FINDINGS AND DISCUSSION

A. INTRODUCTION

During the encoding process, the following pattern of activities were observed. The subjects frequently performed independent activities, within the same episodic classification, for an extended period. The numeric representations of these episodes were first examined for consistency in coding within the activity period. This was done primarily for verification of the coding validity. The results of the evaluation of the coding scheme within the different activity periods were found by the research facilitator to be consistent throughout the entire process.

The next activity was to examine episodic activity in sequence from first activity to last activity. The results of this indicated that all subjects performed the same types of activities in essentially the same order throughout the design process. A global evaluation of the numeric representation confirmed this conclusion, and indicated that the problem solving activity was an iterative process. The pattern of episodic activity indicated that the subjects had divided the design process into different levels and worked at each level in the same manner.

Based on the data encoded the remaining parts of this chapter focuses on the development of the process model and the specific behaviors of the subjects during task performance.

B. PROCESS MODEL DEVELOPMENT

The design process used by novice systems analysts consists of four phases. These four phases are the goal formulation phase, identification of relevant data phase, hypothesis generation phase and hypothesis confirmation phase. A graphic model of this process is provided in Figure 1.

1. Goal Formulation

The initial activity engaged in by each of the subjects was goal formulation. These goals were broad statements of intended actions. The goals were mostly concerned with the procedural aspects of developing a data flow diagram instead of identification of problems and developing solutions.

While goal formulation was the initial activity of each subject, it was not restricted to the initial period of activity. Development of the initial goals into sub-goals occurred throughout the design process. The sub-goals were also primarily concerned with procedural aspects or the technicalities of the data flow diagram development process.

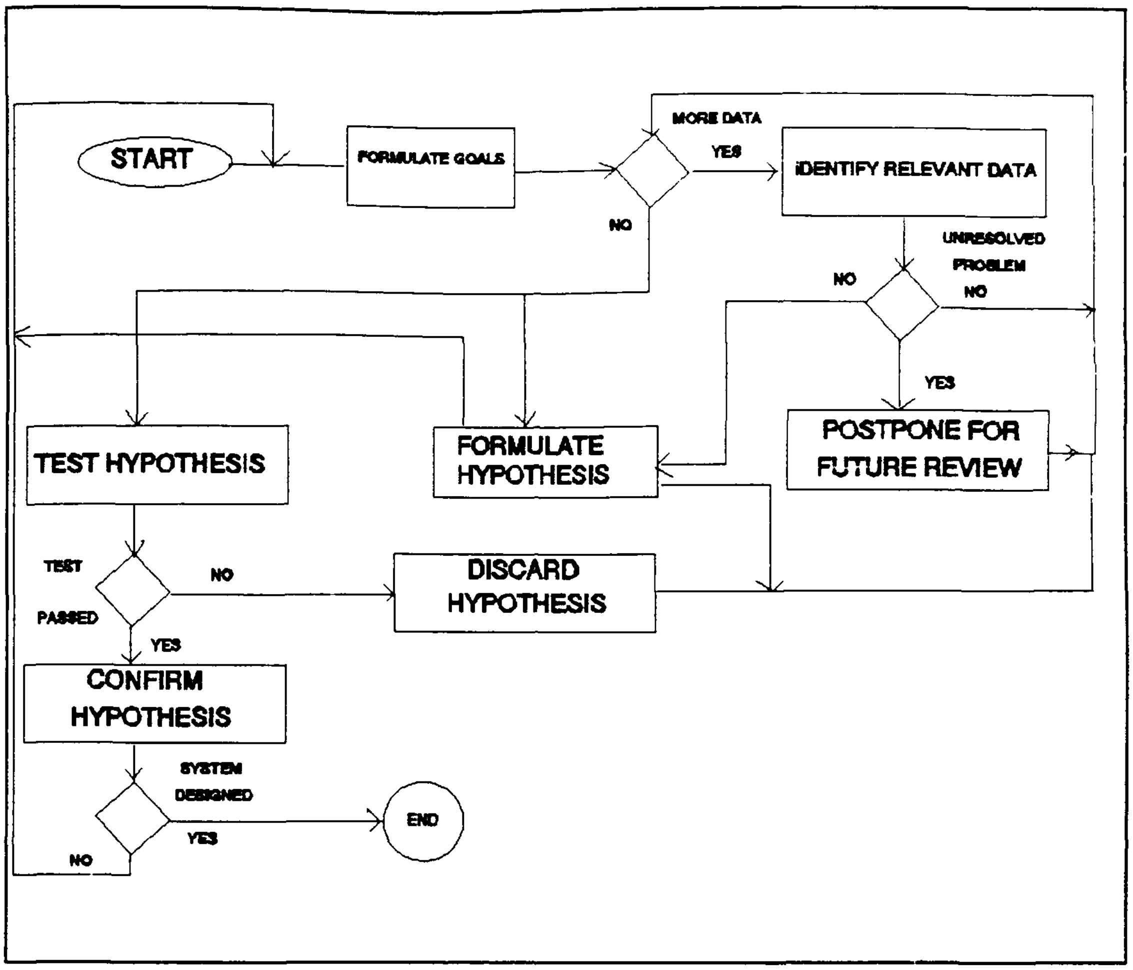

Figure 1: Novice Systems Analysts' Process Model

However, at the sub-goal level there were some goals that were concerned with the performance of activities within an element of the data flow diagram such as a specific process like "start a service". This dynamic process of formulating goals and sub-goals was probably the result of the iterative processes associated with the development of a data flow diagram.

It was stated earlier that the goals of the subjects were very broad. This vagueness coupled with the magnitude of the task and the numerous details that had to be accounted for may have contributed to the difficulty that all subjects experienced in keeping track of events not being directly acted on at the time.

2. Identification of Relevant Data

In this phase, the subjects extracted and examined in extensive detail all the information contained in the customer interview write-up. The relevant information was categorized as entities (internal or external), data, or processes in the system. The subjects then set out to establish relationships between the data, the entities and the system in a format which would accommodate the desired functionality.

It was during this phase that problems were encountered. These problems were associated with how to represent data or how a specific event would affect a larger whole. As previously stated they were very specific problems of limited scope. These problems were either resolved when discovered or set aside for future use.

The subjects' interest in data was primarily quantitative. The search for data was a broad-based search. The attitude was look at everything, because all data were perceived as important. So much effort was expended looking at all of the data that there was little energy left for looking at any data in detail. Data were for the most part taken at face value. For example, There was an entity called "customer". However, the customer could be a new customer or an existing customer. The utility's accounting and engineering departments could also be customers. None of the subjects was able to designed their system to include all the customer types through all the processes. Usually, only two of the four customer types were considered throughout the entire design process. However, each of the four customer types did require unique processing in at least one of the requests. This meant that duplication of efforts was not a valid reason for overlooking the different types of customers.

3. Hypothesis Formulation

During this phase the subjects developed a single hypothesis for the specific process upon which they were working at the time. The hypothesis developed were directed towards getting a process requested by the customer through the various levels of the data flow diagram. Hypothesis were generated for processes at every level required to fully illustrate the processes satisfactory from start to completion.

The subjects did not try to find a best way to build a system. Their action was to find any way to build a system. They would generate a hypothesis, and if that hypothesis passed testing, it was accepted.

Another problem was that the subjects would generate a hypothesis, and then apparently forget about it. This could be attributed to undefined goals or it may have been indicative of under developed indexing abilities in the systems analyst's domain.

4. Hypothesis Confirmation

The subjects design rational concerning hypothesis formulation and confirmation was very direct and very narrow in scope. The first action was to formulate a hypothesis. The subjects then determined if the hypothesis could be tested with data already extracted from the handout. If the hypothesis could not be tested with the available data, the subjects would search for more data. If the hypothesis could be tested with the available data, the subjects would test the hypothesis. If the hypothesis passed testing, the subjects confirmed the hypothesis. If the hypothesis failed testing, the subjects discarded the hypothesis and started the process over.

The testing consisted of actually running the process or data through the entire developed portion of data flow diagram and verifying that all the necessary events occurred (desk-top testing). If the hypothesis passed the test, it was confirmed and the subject continued with the iterative design process. If the hypothesis did not pass the test it was discarded and the subject would either formulate a new hypothesis right then or return to the data gathering phase.

C. IDENTIFICATION OF THE NOVICE ANALYSTS' BEHAVIORS

Constructing the process model is just the first step in the analysis of the problem solving behavior of the novice systems analyst during the design process. In many ways it can be considered a quantitative evaluation, providing a global perspective from which to view the problem solving behavior. But, more importantly it provides an organized framework from which further analysis and qualitative evaluation of specific behaviors can be conducted.

The results of this qualitative evaluation provides meaningful insights into the problem solving behavior of the systems analyst during the design process. This information may be compared to similar information about novices in other fields to identify systems analyst's unique attributes (Ramesh, 1989). However, the greatest benefit from the information obtained from this analysis is that may be compared to results of similar studies of expert systems analyst to identify differences in expert-novice problem solving behavior (Vitalari, 1981).

The following are findings from the qualitative analysis of the process model. Novices:

- Set broad, poorly structured goals.
- Relied on their ability to apply the data to the methodology.
- Frequently referenced the handout to ensure all the data was accounted for.

- Used a iterative design methodology.
- Allowed methodology to lead them through the design process in an unorganized fashion.
- Retained the same methodology throughout the design process.
- Recognized the importance of user participation in the design process.
- Recognized their shortcomings and the need to consult others about their activities.
- Did not use heuristics.
- Did not have preconceived expectations. They asked very few questions during the question answer period.
- Did not readily recognize when errors had been made.
- Spent little time checking their work.
- Did not consider intra-organization politics during the design process.
- Were not concerned about training and implementation.
- Accepted data at face value.
- Did not restrict their problem space to a manageable size.
- Exhibited a lack of confidence in their action.
- Did not evaluate the quality of their hypotheses.
- Were able to identify complex relationships between data.
- Were unable to incorporate their initial impressions of firm into their design process.
- Used desk-top testing to confirm hypotheses.
- Discarded hypotheses when data did not support the desk-top testing.
- Did not seek problems or clues. Novices solved problems as they were encounter or set them aside for later resolution.

In Chapter IV these findings are compared with finding from earlier studies to identify expert-novice and novice-novice differences.

IV. ARE NOVICE SYSTEMS ANALYSTS DIFFERENT FROM THEIR EXPERIENCED COUNTERPARTS? - A COMPARATIVE STUDY

To understand expert-novice differences, it is useful to study the characteristics of expert behavior as established by prior work. These characteristics can then be compared to those of novices in our study to identify areas of potential differences.

A. CHARACTERISTICS OF EXPERTS

Expertise is most often exhibited by individuals in a single domain and most characteristics that experts possess are necessarily domain specific. However, the following characteristics have been noted in most experts regardless of their domain.

- Experts are specialists and exhibit their expertise primarily in the domain of their specialty. Intelligent people may be that way because of the indexing of Long Term Memory in their domain specialty rather than the global quality of their thinking (Minsky and Papert, 1974).
- Experts exhibit superior perceptual skills within their domain. As shown in a study of GO players, experts are able to see larger patterns than novices (Reitman, 1976).
- Experts are faster and more accurate than novices. That can be the shown through the development of automatic skills by practice such as in typing which frees up memory capacity for the other task essential to typing such as reading or taking dictation (Chi, Glasser and Farr, 1988). It may also be shown in the large meaningful patterns that experts perceive within their domain, therefore,

eliminating many of the search routines that novices would have to perform. Cab drivers will recognize a shorter route while traveling to their destination, even though the route was not identified in advance in a laboratory setting (Chase, 1983).

- Experts have expanded Short Term Memory within their domain through the automaticity of many portions of their skills. Normal Short Term Memory is 10-18 digits, however, trained memory experts can remember up to 80 digits in short-term serial recall. (Chase and Ericsson, 1982).

- Experts see through the superficial attributes of a problem to its deeper meaning. Expert programmers will group programs by algorithms while novices will group them by their application (Weiser and Shertz, 1983).

- Experts will spend a lot of time before starting to solve the problem, just thinking about it, in order to obtain a better understanding of how they should go about solving the problem . Novices just tend to plunge in immediately and work towards a solution haphazardly (Chi, Glasser and Farr, 1988).

- Experts will check their work more often than novices and seem to better recognize when they have made errors that need correction before continuing (Chi, Glasser, and Farr, 1988).

Ramesh (1989) used episodic knowledge obtained from the transcriptions of the verbal protocol to develop process models for representing the problem solving behavior of expert and novice financial analysts. He found that expert financial analysts solved their problems in three distinct phases referred to as the situation assessment phase, hypothesis generation phase, and the diagnostic evaluation phase. Within these distinct phases specific activities were exhibited by the expert financial analysts. The situation assessment phase included goal formulation, examination of key areas, and formulation of initial impressions. The hypothesis generation included select and analyze relevant data. Finally, the diagnostic evaluation phase consisted of identification of causes, criticality assessment and identification of other key areas.

These findings will be compared and contrasted with the results of the analysis from this study to identify any expert-novice differences.

Vitalari (1981) used operator representation technique, involving the identification and use of knowledge elements and operator elements to study systems analysts' problem solving behavior. He categorizes expert behavior into different types of search behavior, problem perspective and focus.

The different types of search behavior are the search for triggers or clues, search for goals which limit the magnitude of the search area, search for different strategies from which to approach the problem in order to maintain flexibility, and the search for applicable hueristics used for reducing the search time (Vatalari, 1981).

Experts were determined to have a global problem perspective (Vatalari, 1981). This was determined to be consistent with the concepts of hierarchical decomposition and modularity associated with structured analysis techniques (Gane and Sarson, 1979).

The focus was primarily concerned with the different orientations from which to evaluated and solve the problem.

There was the report-orientation, job-orientation, political-orientation, involvement-orientation, management-orientation and facilitation focus (Vatalari, 1981).

Expert-novice differences will be identified by comparing Vitalari's (1981) findings concerning how expert systems analysts developed and executed their search behaviors, problem perspectives and basic orientations to approaching the problem to findings in this study of novice systems analysts' problem solving behavior.

B. CHARACTERISTICS OF NOVICE SYSTEMS ANALYSTS AND DESIGN

Ramesh (1989) found that novices, like experts, solved problems in three distinct phases. These phases were different from that which the experts used in their problem solving behavior. The phases were problem identification, hypotheses formulation and final diagnosis. Each phase included different activities. The problem identification phase included goal identification and indication of problems. The hypothesis formulation phase activities were group related findings and identify consistent findings. The final diagnosis phase activities consisted of identification of causal linkages and final diagnosis (Ramesh, 1989).

The problem solving behavior of novice financial analysts identified in Ramesh's (1989) study was compared to problem solving behavior of novice system analyst identified in this study to identify novice-novice differences and characteristics unique to novice system analysts.

The novice-novice differences that were identified are presented in the following section.

C. NOVICE-NOVICE DIFFERENCES

Novice-novice differences refers to the different behavior exhibited by members from different domains while performing a domain specific task. In order to identify novice-novice differences, novices' protocols from different domains are analyzed using the same method of representation. This methodology enables the researcher to identify the differences in the problem solving behavior between the two domains and also allows for generation of hypothesis about behavior which may be unique to a specific domain or common to all domains.

While analysis of the problem solving behavior of members from two different domains is too limited a field to confirm hypotheses about the uniqueness of domain specific problem solving behavior, the analysis of the problem solving behavior of members from two different domains does allow for the formulation of hypotheses that can be investigated in future studies.

1. Systems Analysts-Financial Analysts Differences

Financial analyst problem solving behavior consisted of the problem identification, hypothesis formation and final diagnosis phases (Ramesh, 1989). This differed from the problem solving behavior of novice systems analysts in which four distinct phases consisting of goal formulation, gathering of relevant data, hypothesis formulation and hypothesis confirmation were identified.

Identifying symptoms or clues to problems to be solved was a primary consideration of financial analysts (Ramesh, 1989). This activity was not important to the systems analysts. The systems analysts were interested in obtaining data to support the development of a design following a methodology. Problems that systems analysts encountered were a hinderance to task performance, and not the primary consideration of the systems analysts. They were something that needed solving so that designing the system could continue.

Goal formulation and identification of problems are episodic events within the financial analysts' problem identification phase (Ramesh, 1989). The financial analysts' goals were not well defined and used generic terms (Ramesh, 1989). The novice systems analysts' goals were not any clearer or better defined goals, however, they were technical in content. Novice systems analysts' goals indicated that they were going to commence an activity that was specific and structured. While novice systems analysts did not specifically state what they were going to do within framework of that structured methodology, the fact that they were going to participate in a very structured activity implies that the primary orientation of novice systems analysts is technical with secondary consideration given to managerial factors such as the business environment and the overall strategy of the organization. This is different from the novice financial analysts who are concerned primarily with managerial issues such as health of the firm, business environment and strategy. The novice financial analysts use ratios, graphs and statistical analysis as tools to aid managers in their job of achieving the company goals.

The primary difference in the hypothesis formulation phase was that the financial analysts would formulate a hypothesis which had to be justified by significant findings (Ramesh, 1989). If the findings did not lead to the formulation of a plausible hypothesis, then the data would be discarded. The novice systems analysts' hypotheses did not require significant findings in the Hypothesis Formulation phase to justify its validity. In the Hypothesis Formulation phase of the novice systems analysts nothing was discarded.

The hypothesis confirmation phase of novice systems analysts differs from the final diagnosis phase of novice financial analysts in several ways. The primary activity within the hypothesis confirmation phase of novice systems analysts is the testing of the formulated hypothesis. It is during this phase that a hypothesis will be discarded if data do not support it. There is no similar activity within the Final Diagnosis phase exhibited by novice financial analysts.

Also systems analysts do not attempt to integrate the findings. The systems analysts' task is an iterative process within the framework of the formal structured methodology. The fully developed structure is the final product.

2. Systems Analysts Specific Events

Systems Analysts were unique in at least two aspects. During goal formulation the novice systems analysts committed to a formal structured methodology for performing the assigned task. Second, after the systems analysts formulated goals they would gather data and formulate one hypothesis that fit the data to the structure and then test the hypothesis. A the successful testing resulted in hypothesis confirmation. This format in which the novice system analysts would formulate a hypothesis, test the hypothesis and then confirm or discard the hypothesis based on the ability of the data to support the hypothesis was unique to systems analysts.

D. EXPERT-NOVICE DIFFERENCES

The next sections describe the expert-novice differences obtained from comparisons of novice systems analysts' problem solving behaviors with expert financial/systems analysts' problem solving behaviors.

1. Episode Representation Differences

The comparison of novice systems analysts and novice financial analysts discussed earlier indicated that there was sufficient similarity for comparison between the two groups.

Ramesh's (1989) work with expert financial analysts using episode representation to model and analyze their problem solving protocols provides an excellent opportunity for such a comparison. In this section we will compare behavior of expert financial analysts and novice systems analysts. The major differences between the two categories are as follows:

- Experts stated their goal clearly and referred to them frequently. Novice goals were broadly stated, technical in wording and not frequently referred to after initially stated.

- Experts started their analysis with an initial impression of the firm which helped them form expectations and develop list of potential problem areas. Novices form initial impressions of the firm and then disregarded them once the design process started.

> Experts Spend a Great Deal of Time Analyzing a Problem Qualitatively. Protocols show that, at the beginning of a problem-solving episode, experts typically try to "understand" a problem, whereas novices plunge immediately into attempting to apply equations and to solve for an unknown. What do the experts do when they qualitatively analyze a problem? Basically they build a mental representation from which they can infer relations that can define the situation, and they add constraints to the problem.... (Chi, Glasser and Farr, pp. xvii-xx, 1989)

- Experts searched for clues to support or negate their hypothesis during the hypothesis generation phase. Novices accepted their hypotheses at face value. Novice system analysts did not evaluated their hypotheses until the Test Hypothesis phase.

- Experts looked for "good" and "bad" signals in the data they analyzed to be used for correcting initial hypothesis in case there were discrepancies. When a novice formulated a hypothesis it was accepted as is or discarded. The quality of the hypothesis was not a consideration.

- Experts were able to identify and maintain in their minds complex relationships between various segments while analyzing data. Novices could identify complex relationships within segments and across various segment, but could not maintain the relationships while analyzing the data.

- Experts had preconceived ideas of "key areas" that required examination. This was probably the result of past experience in solving similar problems. Novices did not assign special meanings to parti ilar areas, but rather looked at all areas in the order that was presented in the case write-up. Novices have very limited practical experience, therefore, they are not able to generated preconceived ideas of what to expect or look for, but must look at every thing in total.

- Experts ranked their hypothesis in order of importance. Novices did not rank their hypothesis. There were indications that the novices recognized that certain hypothesis were more important than others, but these hypothesis were not given any special consideration.

- Experts were interested in the firm's goals and strategies, both internal and external to the organization. Novices' interests in the firm were related to how the customer service system would interact with different functional areas internal to the organization.

- Experts were interested the managerial style of the firm and the business environment in which the firm operated. Novices were only interested in the system which they were designing.

2. Knowledge Operator Differences

Nicholas P. Vitalari (1981) used knowledge operator representation to analyze the problem solving protocols of expert and novice system analysis. The following behavioral differences were the results of a comparison between the findings of this study and Vitalari's work. Experts:

- Set specific well structured goals. Novice set broad poorly structured goals.

- Developed multiple strategies for achieving the goals. Novices did not develop a strategy. They allowed the methodology to lead them through the design process in an unorganized fashion.

- Would modify or discard a strategy when evidence indicated that the goals were not being achieved. Novices stayed with the same methodology throughout the process.

- Applied heuristics during the problem solving process. There was no indication that the novices used heuristics at any time during the process.

- Were aware and showed consideration for the political attributes of the firm such as territorial consideration and orders of priority on who initiated and responded to various actions. Novices recognized that there were different areas of authority, but treated each as an equal partner.

- Were concerned about the organizational behavior such as the "resistance to change" phoneme. Novices were only interest in designing a system. They did not consider how this would affect the organization.

- Were concerned about the skills of the individuals within the organization. Novices did not show any interest in the skills of the people within the organization. There was no concern for staffing requirements for operating and maintaining the system after implementation.

- Were interested in how the secondary data could be formatted and used by upper management in addition to the uses at the operational level. Novices were only concerned with getting a workable system to the operational level.

- Showed concern for more than the end product. They were interested in things like peoples names showing a personal orientation. Novices were only interested in the product.

- Searched for clues about the problem for use in formulating goals and strategies. The novices took all the data at face value.

- Had expectations and their search is characterized by what is missing instead of what is apparent. Novices search for data is a rehashing of what is apparent.

- Were interested in the organization structure for use in developing maps and strategies to use during the problem solving. Novices relied on the structure of the methodology and how raw data fit into the structure.

- Used goals to manage the size of the problem space. Novices did not set good goals and it was apparent from the data loss during the design process that the problem space was larger than the novice could effectively manage.

- Exhibited behavior which is meant to reduce uncertainty. Novices exhibited a lack of confidence in their ability to design the system. Their action increased the uncertainty.

V. CONCLUSION

This study of the problem solving behavior of novice system analyst had three objectives:

- To analyze the problem solving behavior of the novice system analysts during the design process.
- To compare the results of this study to those of previous studies involving experts and identify the differences.
- To suggest possible uses for the differences.

Protocol Analysis provided a methodology for the analysis of the problem solving behavior of novice system analysts. Similar studies have been conducted using experts. Ramesh's (1989) studies of expert financial analysts using episode representation and Vitalari's (1981) work with expert systems analysts using knowledge operator representation were two of these studies.

The findings of this study suggest that there are significant differences between expert and novices, in the way they perform systems analysis and design. Suggested ways to use these differences are provided in the following paragraphs.

The first and most obvious use for the findings is in the traditional instructor-student relationship. By calling the experts behavior the goal and the novices behavior the current situation, educational programs can be designed and implemented to practice those specific things that experts do and that novices do not do. Specifically efforts are directed towards known activities in which experts participate.

The second and more remote use of the findings is in the development of intelligent tutoring systems. This method of education does not use a human instructor, but rather the student and a machine interact in a learning environment.

Currently, the bottleneck in the development of effective expert systems is in the area of adequately modeling the behavior of experts for the systems. The availability of the behavioral models and expert-novice differences could assist with the development of expert or intelligent tutoring systems for systems analysts.

Third, CASE technology currently provides users with tools that automatically generate code, create and maintain a data dictionary, write and update all required documentation and performs other tasks currently associated with systems development just by using various data flow and entity diagrams as input. The output is consistent and technically correct, however, the output is only as good as the diagrams that are used as input to the CASE tool. If the quality of the analysis and diagram development used for input to the CASE tool are poor, then the resultant output is a consistent and technically correct poor system.

A potential use for the results of this research is to build an expert system as a front-end processor to a CASE tool. The front-end processor would be used to evaluate the level of expertise of the analyst using the tool. By understanding the differences between the skills of the analyst providing the input and an expert analyst's skills, the front-end processor can improve the quality of input thereby ensuring the code and other generators operate using the best possible input.

Appendix A: AN OVERVIEW OF PROTOCOL ANALYSIS

A. PROTOCOL ANALYSIS DEFINED

A generic definition of Protocol Analysis is given below.

> Protocol analysis is a general term for the collection and analysis of verbal reports made by subjects while they perform a task. (Vitalari, p. 81, 1981)

Ericsson and Simon (1984) broaden the scope of this definition by allowing for two types of verbalization. The first is a verbal report where subjects talk aloud while performing a task, referred to as concurrent verbalization. The second type of verbalization is a report made by subjects subsequent to the performance of a task, referred to as retrospective verbalization.

B. OVERVIEW OF THE COGNITIVE PROCESS

A primary assumption behind Protocol Analysis is that an individual's problem solving behavior can be determined from analysis of the subject's verbalizations. These verbalizations consist of interactions between information contained in Short Term Memory (STM) and Long Term Memory (LTM).

1. Short Term Memory

STM is a recording of events and stimuli which an individual has experienced recently. STM capacity is minimal, though there is some variance between individuals. It is instantly available, not requiring retrieval delay. STM duration can vary from that of a fleeting nature to moments. However, the longer the information that an individual is consciously aware of, or "heeded" remains in STM the greater the probability that it will become contaminated by the information previously stored in LTM, thereby losing its original identity. This does not preclude the possibility that the "heeded" data may have already been stored in LTM prior to contamination. The probability of data storage in LTM is dependent upon the duration that it is "heeded" in STM.

> It is even more obvious that information can be retrieved from LTM only if has been stored there previously, and retained. The hypothesis about storage (fixation) that seems to us most defensible in the light of the empirical evidence is that if and only if information is heeded in STM for a sufficient interval of time will it be stored (and indexed) in LTM. (Ericsson, Simon and Herbert, p.81, 1984)

Finally, STM is the gateway through which all interactions - passive and active with LTM are routed.

2. Long Term Memory

LTM is an accumulation of all the events or stimuli that an individual has experienced and "heeded" during their life. Access to LTM compared to STM is slow yet, its capacity is virtually unlimited.

Demonstrated ability to retrieve obscure facts from the voluminous amount of information that an individual has stored in LTM over a lifetime of experiences seems to imply that LTM is indexed in some fashion. This indexing or categorization in many instances is highly organized and can be rapidly retrieved as demonstrated in studies of the "tip of the tongue" (James, 1890) and "felling-of-knowing" (Woodworth, 1938) phenomena.

A simplified view of accessing or retrieving information from this indexed or categorized LTM is to visualize a set of symbols formulated in STM which cause electrical impulses to activate locations in LTM. As a result data in the activated locations are copied into STM. This process, depending on a variety of factors, can be almost instantaneous, approaching the time required to access STM or it can proceed over an extended period. The degree of accuracy of the data retrieved from LTM can vary. This variance occurs because the indexing or categorization is dependent upon the relationships between data stored in LTM. The longer the data are stored in LTM, the greater the probability that the boundaries between the relationships that characterize different but similar data will merge. This merging of boundaries results in data stored in LTM acquiring characteristics not present when initially "heeded".

C. PROTOCOL ANALYSIS AS A RESEARCH METHOD

Protocol Analysis is a valid methodology for identifying the cognitive processes of individuals during task performance (Ericsson and Simon, 1984). It provides the researchers with several ways to analyze problem solving behavior.

1. Types of Protocol Analysis

Protocol analysis is typically conducted using two different techniques. The techniques can be used separately, or in conjunction with, each other. The first method, retrospective analysis, requires the subject to perform a task, and after the task has been completed the subject verbalizes what he is thinking about as he performs the task. The second method, concurrent analysis, requires the subject to verbalize as he is performing the task. When the two methods are used in conjunction, the subject is asked to verbalize while performing the task, and then after task completion the subject is asked to reflect on his thoughts during task performance.

The effectiveness of these two analysis techniques are briefly discussed below.

a. Retrospective Analysis

Retrospective analysis is very susceptible to inaccuracies. The primary reason is that retrospective analysis requires the subject to verbalize about an event that has occurred sometime in the past. If the event that the subject is responding to occurred in the recent past, portions or even all of the "heeded" data may still reside in STM. However, as stated earlier, the possibility for contamination of data in STM increases as the duration of "heeded" data in STM increases. If the data to be verbalized are no longer in STM, then the subject has to initiate the retrieval of the desired information from LTM to STM for encoding and verbalization. In summary, information retrieved from LTM may be inaccurate for several reasons:

- The information that has been stored in LTM is not always initially retrievable in total.
- Over time, the boundaries in LTM weaken resulting in the merging of data of a similar nature.
- The subject may misunderstand what is requested and provide inaccurate data, even though it may be relevant.

b. Concurrent Analysis

Concurrent analysis is not as susceptible to the inaccuracies associated with retrospective analysis. Since, the subject verbalizes his thought process as he performs the task, there is little chance that the information is contaminated.

2. Issues in Using Protocol Analysis as a Research Method

The purpose of this thesis is to use protocol analysis to analyze the problem solving behaviors of novice systems analysts during task performance. However, there are several concerns about the validity of protocol analysis as a research method that need to be addressed first. These concerns are:

- Doubts have been expressed about using verbalizations as data (Ericsson and Simon, 1984).
- Concerns have been raised about the spontaneity of the subjects verbalization (Ericsson and Simon,1984).
- It has been suggested that the verbalizations are "soft" data e.g. they are subjective and not measurable (Ericsson and Simon, 1984).
- Theoretical presuppositions during the encoding process have to be considered (Ericsson and Simon, 1984).
- Can the subject be trusted to not to be deliberately misleading with their verbalizations (Ericsson and Simon, 1984)?

The following sections address these concerns.

a. Response to Doubts

The doubts expressed by many psychologists about the suitability of subjects verbalizations as scientific data have to do with introspection. Psychologists argue that retrospective analysis is a variant of the discredited process of introspection (Ericsson and Simon, 1984). However, there is a significant difference between protocol analysis and introspection. Protocol analysis requires the subjects to verbalize their thoughts as they occur. This is possible because of the invention and availability of tape and video recorders. On the other hand, introspection involves a trained domain specialist, usually a psychologist, reflecting on his own problem solving activities and writing or dictating to a stenographer an analysis of these activities. This process has all the previously mentioned problems associated with retrospective analysis, in addition to any preconceived biases of the person doing the introspection.

b. Influencing Verbalization

To obtain data suitable for the type of protocol analysis selected for use, a methodology must be developed to influence the subject's verbalization. Through careful wording of the instructions, different kinds of verbalizations can be obtained from a subject. Examples of the instructions are:

- "I would like you to say out loud what ever thoughts come into your mind, as if you were in a room alone talking to yourself."
- "I would like you to talk aloud as you are performing the task."
- "I would like you to verbalize what you are doing as you are doing it and why you are doing it"

The first two constructions are structured to obtain responses suitable for concurrent analysis. The third construction seeks to obtain a hybrid response for use in concurrent and retrospective analysis.

c. "Soft" Data Versus "Hard" Data

Data collected by verbalization are considered "soft" data primarily by people who misunderstand how the verbalizations are going to be interpreted. "Soft" data are obtained when data interpretation occurs simultaneously with the verbalizations. By using this method the interpretation is subjected to the theoretical presuppositions of the interpreter (Ericsson and Simon, 1984).

"Hard" data can be collected and analyzed objectively. An example of "hard data" would be the recording of the time between eyelid movements during task performance. When using protocol analysis the protocols are recorded and transcribed verbatim. This data are just as "hard" as the data about eyelid movement (Ericsson and Simon, 1984).

d. Theoretical Presuppositions During Encoding

With protocol analysis, a subject speaks out loud. The verbalization is recorded and then transcribed verbatim. At this stage there are no interpretations and no inferences, with the exception of some processing as verbal inflections and emphasis are represented by punctuation.

To interpret "hard" data obtained from subjects, verbalizations need to be encoded. The coding process, just by its very nature, is subject to some theoretical presuppositions. The objective when analyzing the subjects verbalizations is to minimize the theoretical presuppositions to facilitate providing an objective as possible analysis of the subjects' behavior. This is done, first by minimizing inferences and expectations used by the person developing the coding scheme. Further, it is accomplished by ensuring the person or persons doing the actual coding of the protocols were not involved with the development of the coding scheme. Finally, the protocols should be coded by at least two people working independently. The results of the codings are then compared and any differences are resolved.

e. *Trusting the Subject*

A basic but absolutely essential concern is how to ensure that the subjects are not purposely misleading researchers during the process (Ericsson and Simon,1984). If the subject was asked in an introspective report about his mental state or thought processes, trust is important and some validation is crucial (Ericsson and Simon, 1984). With protocol analysis, researchers can eliminate the need to trust the subjects and collect the data required for determining problem solving behavior during task performance during the same process.

> However, the issue of the reliability of self-reports can (and, we think, should) be avoided entirely. The report "x" need not be used to infer that X is true, but only that the subject was able to say "X"_(i.e., had the information that enabled him to say "X".) by following this path, we can even show that there is an inverse relation between how much subjects need to be trusted and how much information they verbalize. For the more information conveyed in their responses, the more difficult it becomes to construct a model that will produce precisely those responses adventitiously-hence the more confidence we can place in a model that does predict them. (Ericsson, Simon and Herbert, p.7, 1984)

D. SUMMARY

Verbalization is an activity of the cognitive process that is recordable for analysis. Protocol analysis provides the means to capture and analyze verbalizations during task performance in order to identify problem solving behavior. It is a methodology in which minimal theoretical presupposition is required for use, thereby, increasing the objectivity of the analysis of the data. When using protocol analysis the issue of trusting the subjects is not a concern. These factors make protocol analysis a valuable tool that should continue to be used and refined.

Appendix B: CUSTOMER SERVICE SYSTEM

Southeast States Power, a gas and electric utility company, is automating a major part of its customer service system. The proposed system should utilize a centralized telephone answering service center, connected by an online computer to a large number of field stations. The central system will be installed with the objectives of providing quick processing of requests and providing accurate information to customers about the status of their requests. In the centralized set up, calls from customers will be routed to any clerk available at the service center. Further, requests for service may originate from within the utility itself. The accounting department may request cancellation or restoration of services based on the payment profile of customers. The engineering department may request setting up or removal of services from a location.

The proposed system will support the following types of request:

- starting a service
- stopping a service
- switching a service from one location to another
- setting up a location for service
- removing service from a location

- restoring service to a customer with local outage
- restoring service to customers after system-wide outage
- maintaining and repairing appliances

The clerks generate service orders based on the request for service. Records maintained by the system contain information about the customers, location, equipment and appliances at the location,a and status of system-wide service. The clerks retrieve relevant information from internal records while generating service orders. The clerks submit the service orders to the service center supervisors for their authorization. the supervisors forward authorized service orders to field station supervisors for follow up.

While processing a request from a customer for starting a service, the clerk obtains authorization from the credit department. Further, the clerk ascertains the need for requesting a deposit from the customer. If the customer is requesting that the service be stopped, the clerk should terminate any contracts for maintenance of appliances that have been entered into with the customer. The requests for switching service from one location to another will involve starting a service in the new location and stopping the service at the old location. While processing the request for setting up and removing service from a location, the clerk obtains details about the location and equipment used in the location so that internal records can be updated. When a customer reports an outage, the status of the system-wide service should be checked before orders are placed for follow up. When requests for repairs of appliances are received, the clerk checks appliance maintenance contracts to ascertain charges (if any) for customer billing.

Field station supervisors set priorities on service orders and then group them based on the location and nature of service to be provided. Field technicians with necessary skills (such as appliance repair, equipment set up etc.) are dispatched to provide service. After providing the service, field technicians report the status of the order (such as the nature of the service provided and completion status) to the field supervisors. Field supervisors reconcile this information with the service orders. Appropriate charges (if any) are computed and communicated to the accounting department for customer billing.

The clerks provide information about the status of the service requests upon inquires from customers. They also notify service center supervisors when complaints about delayed or inadequate services are received.

CUSTOMER SERVICE SYSTEM PROCESS DESCRIPTION

CALCULATION OF DEPOSITS

Compute the deposit to be paid by the customer based on the type of customer (residential or industrial), the past consumption pattern (if available, is maintained for a 12 month period) or expected consumption as follows:

Industrial Customer

The deposit required is based on the maximum monthly consumption from the consumption history. The actual value is:

max_consumption * a constant (say 1.5) * approximate rate per unit (say $0.1 per unit).

When the history is not available, the maximum monthly consumption is computed as proportional to the installed capacity of the industrial unit. The actual value is:

Installed capacity * a constant (say 2.0) * approximate rate per unit (say $0.1 per unit).

Residential Customers

the deposit required is based on the average monthly consumption from the consumption history. The actual value is:

average consumption * a constant (say 2.0) * approximated rate per unit (say $0.08 per unit)

When the history is not available, the average monthly consumption is based on the type and size of the house/apartment to which the service is provided. Expected consumption is maintained as a table of the following form:

Type of House	Size (room)	Consumption
Town House	4	300 units
Condo	2	100 units

The actual value is:

Average consumption * a constant (say,2.0) * approximate rate per unit (say, $0.8 per unit)

(The following information was not given to the subject. It was used for clarification during the question answer session.)

CUSTOMER SERVICE SYSTEM CLARIFICATION FROM CLIENT INTERVIEW

The proposed system will support the following types of request:

- starting a service: starting a gas/electric service as a customer's location.
- stopping a service: stopping a gas/electric service at a customer's location when the customer moves out of the area serviced by the utility company.
- switching service from one location to another: when a customer moves from on location (old location) to another location (new location) that is also service by the utility company, service is discontinued in the old location and started in the new location.
- setting up a location for service: setting up a location (such as installing appliances, meters etc.) so that gas/electric service can be provided to customers who will move into the locations. The requests for setting up a location originate from the engineering department.
- removing service from a location: removing equipment such as appliances or meters from a location so that the location will not be serviced by the utility. The requests for removing service from a location originate from the engineering department.
- restoring service to a customer with local outage: local outages are outages that affect the customer only.

- restoring service to customers after system-wide outage: system-wide outages are outages that affect a large number of customers.

- maintaining and repairing appliances: stoves, furnaces, ovens etc. are examples of appliances.

- Each field station provides service to part of the total geographical area serviced by the utility.

- Field supervisors obtain information about the status of the orders from technicians and enter this information in the system. This status information is available to telephone answering center clerks for answering queries from customers.

TELEPHONE SERVICE CENTER

- The clerk receives requests from customers as well as the accounting and engineering departments of the utility. Activities leading to the generation of requests at the engineering and accounting departments is beyond the scope of the system.

- The clerks processes the requests and sends them to supervisors for authorization and further action.

- The clerks have access to credit information about the customers (that is created an maintained by the credit department). This credit information specifies whether any deposit is required from the customer while processing the request. The amounts of deposit is calculated by the system using a pre-specified formula. The clerk informs the customers the amount of deposit and payment plans. The billing is handled by the accounting department.

- When new customers whose credit information is not available request that a service be started, the clerk send a request for credit authorization to the credit department. Further, the clerk processes the request from the customer and forwards it to the supervisor for follow up.

- A customer will have separate billing accounts for each of the locations in which he/she gets service. The clerk obtains the name and address of the customer or the account number to process requests.

- A customer may call to ascertain the status of a request made earlier. If the customers complain about delays in service or inadequate services, the clerk forward these complaints to the supervisors.

- Status of system-wide service is available to the clerks. Customer complaints information is not used in determining whether a system-wide problem exists.

- For each appliance installed at a customer's location, information on their type, installation date, service history, maintenance contract details etc. is maintained. The clerk checks the maintenance contract information to determine whether customer needs to be billed for appliance repairs.

- Telephone answering center supervisors authorize the service order and forward them to field supervisors.

- The credit department forwards credit authorization for new customers to the supervisors. Supervisors contact the customers when authorization information is received to inform them the status of their request as well as deposit requirements.

FIELD STATION

- Field station supervisors assign priorities to service orders according to a pre-determined scheme.

- Supervisors assign one technician to process each order.

- When the technician report on the status of the order, their supervisors reconcile the information with the service orders. further, based on the information, the system computes appropriate charges (if any) according to a pre-determined formula for customer billing.

- The information on the status of the service orders is available to telephone answer cente clerks for answering queries from customers.

Appendix C: PERSONAL DATA QUESTIONNAIRE

1. What is your name?

2. What is your branch of service?

3. What is your community? (Aviation, Surface-Line, Submarines, Supply, Intelligence, other)?

4. What is your curriculum and current quarter?

5. What was you undergraduate major?

6. Have you had and computer training prior to attending Naval Post Graduate School? If yes, was it design, programming, databases, other? How many quarters or semesters?

7. Have you ever worked on Systems Development Project? If yes, in what capacity?

8. Have you ever been a subject in a study utilizing protocol analysis?

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