AN EXPERIMENTAL INVESTIGATION OF THE USE OF EXPLANATIONS PROVIDED BY KNOWLEDGE-BASED SYSTEMS

by

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ABSTRACT

Ever since MYCIN introduced the idea of computer-based explanations to the artificial intelligence community, it has come to be taken for granted that all knowledge-based systems (KBS) need to provide explanations. While this widely-held belief has led to much research on the generation and implementation of various kinds of explanations, there has however been no theoretical or empirical evidence to suggest that 1) explanations are used by users of KBS, and 2) the use of explanations benefits KBS users in some way. In view of this situation, this study investigates the use of explanations that are provided by a knowledge-based system, from the perspective of understanding both the specific factors that influence it, as well as its effects.

The first part of this dissertation proposes a cognitive learning theory based model that both clarifies the reasons as to why KBS need to provide explanations and serves as the basis for conceptualizing the provision of KBS explanations. Using the concepts of the feedforward and feedback operators of cognitive learning it develops strategies for providing KBS explanations and uses them to classify the various types of explanations found in current KBS applications. The roles of feedforward and feedback explanations within the context of the theory of cognitive skill acquisition and a model of expert judgment are also analyzed. These, together with past studies of KBS explanations, suggest that user expertise, the types of explanations provided, and the level of user agreement are significant factors that influence the explanation seeking behavior of users. The dissertation also explores the effects of the use of KBS explanations in judgmental decision making situations supported by a KBS. It identifies and considers four distinct categories of potential effects of the use of explanations --- learning effects, perceived effects, behavioral effects, and effects on judgmental decision making.
The second part of the dissertation empirically evaluates the explanation provision strategies in a laboratory experiment in which 80 novice and expert subjects used a KBS for financial analysis to make judgments under conditions of uncertainty. The experiment was designed specifically to investigate the following fundamental research questions: 1) To what extent are the various kinds of explanations used? 2) How does user expertise, the feedforward and feedback provision of explanations, and the level of user agreement influence the amount and the types of explanations that are used? and 3) Does the use of explanations affect the accuracy of judgmental decision-making and user perceptions of usefulness?

Some of the major results relating to the determinants of the use of KBS explanations include: 1) user expertise is not a determinant of the proportion of explanations used but influences the types of explanations that are used, 2) explanation provision strategy is a critical determinant of the use of KBS explanations with feedback explanations being used significantly more than feedforward explanations, and 3) the three types of explanations are used in different proportions with the Why and How explanations being used significantly more than the Strategic explanations. It was also found that the level of user agreement with the KBS had an "inverted-U" shaped relationship with the use of explanations. The least number of explanations are used when the level of user agreement is either very high or very low. The major results relating to the effects of the use of explanations include the following: 1) the increased use of feedback explanations improves the accuracy of judgmental decision-making but has no effect on user perceptions of usefulness, 2) the increased use of feedforward explanations while having no impact on the accuracy of judgments is positively correlated with user perceptions of usefulness, 3) the use of the Why explanation as feedback improves the accuracy of judgmental decision-making. As well, there was also evidence that the use of the KBS benefited both experts and novices. Considering that an understanding of the determinants and effects of the use of KBS explanations is a critical prerequisite for the design of KBS explanations, these and other findings of the study contribute both towards the
development of a theoretical basis for the provision of KBS explanations, as well as the practical design of such explanation facilities.
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Ik Onkar,
Satnam, Nirbhau, Nirvair, Akal-murat, Ajuni
Saibhang, Gurprasad, Jap, Ahd Sach, Jugad Sach, Haibhi Sach,
Nanak Hosi Bhi Sach.

— Japji Sahib

...... this thesis is dedicated to my parents Dilbara and Amritpal
and my sons Simren and Runpal

Ilm Amal

With the beggar’s bowl of my skull
I hankered after those with garnered learning,
Begging crumbs of their knowledge,
Stuffing them into this bowl.
Conceited, puffed with scraps,
Learning’s mantle, I fancied, had fallen upon me,
Strutting like one far gone.
One day I placed my surfeited bowl before the Master:
"Leavings, corrupted crumbs!" he cried,
Emptying it out on the highway;
Then he rubbed it clean of this pollution:
See how it shines now, its lotus-freshness.

— By Bhai Vir Singh, Poet of the Sikhs
CHAPTER 1: INTRODUCTION AND MOTIVATION

1.0 Introduction

The focus of this dissertation is on understanding the factors that influence, as well as the effects of, the use of explanations that are provided by knowledge-based systems (KBS). Knowledge-based systems are computer-based software tools that use artificial intelligence techniques to capture, represent and apply expert knowledge, so as to be able to mimic the behavior of human experts in specific narrowly-defined problem domains. The ability to explain knowledge and reasoning, often referred to as the explanation facility, is considered to be one of their most powerful components. For example, in a survey capturing the preferences of medical practitioners for KBS design features, Teach and Shortliffe [1981] found them to rate the system's ability to provide explanations of its knowledge and functioning as the primary requirement for a KBS in medicine. However, while substantial research efforts have been directed to the implementation of explanation facilities and the generation of explanation texts [see Abu-Hakima and Oppacher, 1990 for a comprehensive summary], surprisingly little is known about the behavioral consequences of explanations as part of the KBS interface. For example, given a choice in acquiring explanatory information, not everyone chooses to use this information. It has been argued that the scant attention paid to such phenomenon, and to the requirements for KBS explanations in general, is a major reason for the limited impact that knowledge-based systems technology has had on computing in general [Kidd and Cooper, 1985]. Similarly, Carroll and McKendree [1987] argue that far too little behavioral work has been invested in research on the design of advice-giving systems and suggest that it is pointless to build such interface facilities unless "we take into account the behavioral requirements of their usefulness and usability."
1.1 Importance of KBS Explanations Research

Ever since explanations were introduced as part of the interface of MYCIN [Scott, Clancey, Davis, and Shortliffe, 1977], it has come to be taken for granted by the artificial intelligence community that all KBS should provide explanations [Duda and Shortliffe, 1983; Buchanan and Shortliffe, 1984]. However, although there exists a substantial amount of literature on the nature and structure of explanation in the philosophy of science [Toulmin, 1958; Hempel, 1965; Achinstein, 1971], the provision of KBS explanations has not been theoretically or empirically studied thoroughly to date. There exist no theories that address fundamental concerns such as: 1) why should KBS provide explanations, and 2) what benefits are there for users of KBS to make use of explanations that are provided? As well, there is little empirical evidence to indicate that when they are provided, KBS explanations are used and useful in problem solving situations. As a matter of fact, the most troubling aspects of the KBS explanations literature is that the goals for providing explanations are poorly explicated, if at all specified, and it is commonly assumed that KBS explanations are relevant to, and necessary for, all problem-solving situations.

Considering that large amounts of time and system development resources are necessary to implement explanation facilities [cf. AAAI Workshop on Explanations, 1988], it is imperative that we should first seek to understand: 1) the circumstances in which explanations are selected for use, and 2) how the use of explanations affects the user as well as the quality and process of decision making. Such an understanding of both the factors that influence, and the effects, of the use of explanations will be invaluable to KBS developers for making design decisions relating to: 1) the optimal design features and strategies to be used for providing explanations, and 2) the appropriate amount of resources that should be expended on developing explanation facilities.
While dictionary definitions of explaining focus on "making clear or intelligible", "giving meaning to", "accounting for", and "making known in detail" [Oxford, 1984], Hayes and Reddy [1983] argue that humans explain for one or more of the following three reasons: 1) to clarify, 2) to instruct, and 3) to convince. For example, explanations are used to clarify why a particular question is being asked, instruct as to how a particular conclusion is reached, and convince by giving reasons as to why all other alternatives are infeasible. While clarifying, teaching and convincing can reasonably be expected to increase the understanding of the person who is provided with the explanations, the fundamental question of whether such an understanding does translate directly into improved problem solving or decision making also needs to be investigated. It is therefore critical that studies be undertaken to demonstrate how the use of explanations improves the quality of decision making.

The study of explanations is also important from the perspective of human-computer interaction and interface design. It is argued that the exact manner in which KBS explanations are provided will directly influence KBS use, as well as the value that users derive from them. The importance of this is underscored by studies of cognitive learning that suggest that the exact nature and timing of explanatory information made available to learners can be expected to significantly affect both their explanation seeking behaviour, and their understanding and comprehension of the domain being learned. Wensley [1989, p. 261] notes that most of the expert systems that have been produced to date have poor interfaces for explanations. For instance, he observes that:

"it seems to be assumed that providing the users with a single type of explanation is sufficient. Usually the explanation is in the form of a tortuous chain of facts and rules which lead to a particular conclusion. Like a mathematical proof, an
explanation of this type is unlikely to inspire confidence. Even more dangerous is the assumption that a single generic explanation can be provided to novice and experts alike. This is clearly unacceptable. There is much research which needs to be done into the nature of explanation from a practical human-computer interface standpoint."

The user interface needs of KBS users are fundamentally different from, and go beyond, those of users of conventional information systems, such as decision support systems. For example, Ye [1990] argues that because traditional programs automate well-specified computational procedures, users are more concerned about operating a system effectively to obtain outputs, than about understanding the validity of the system’s functioning and the usability of its outputs. Designers of KBS interfaces, however, must go beyond operating concerns such as ease-of-use, response time, and error recoverability, to consider those interface needs that are likely to affect user understanding and acceptance of the KBS and its outputs [Hendler and Lewis, 1988; Wexelblat, 1989].

1.2 The Approach Taken By This Study

KBS explanations are used in three different contexts: 1) as part of KBS use in decision making, 2) as part of debugging activities carried out by knowledge engineers, and 3) as part of system validation activities carried out by users, domain experts and knowledge engineers. The distinctions between these three contexts are critical and stem from the fact that while explanations are commonly incorporated into most end user applications of KBS, they can also play a significant role in KBS development. In recognition of this, most current KBS development shells and environments include tools that utilize explanations to aid efficient and effective system development.
The practice of incorporating explanations in *end-user applications* of KBS is based on the dual beliefs that: 1) intelligent advisory systems should be able to explain themselves like human experts, and 2) explanations increase user confidence and understanding by revealing domain knowledge and internal rules leading to system conclusions. Lamberti and Wallace [1990, p.302] suggest that an explanation facility is useful at several levels: 1) explanatory information aids the decision maker in formulating problems and models for analysis, 2) it can assure the sophisticated user that the system's knowledge and reasoning process is appropriate, and 3) it can instruct the novice user about the knowledge in the system as it is applied to solve a particular problem.

The logic behind including explanation facilities in *KBS shells and development environments* is that they provide enhanced debugging and validation abilities in systems development. For example, the REPORT command in the VPExpert [Paperback Software, 1988] shell lists in sequential order all the explanations attached (using the BECAUSE clause) to rules that 'fired' as part of a consultation. Such a listing assists in the debugging of processing logic by knowledge engineers. It also allows users and domain experts, who may not be familiar with representation schemes and inference engines, to participate in the validation of a knowledge-base.

Thus, the use of KBS explanations in systems development is motivated by a different set of objectives than when used as part of an end user application. This study limits itself to the study of KBS explanations that are included as part of end-user applications of KBS.

This study takes a "decision support system (DSS)" approach to the investigation of KBS explanations, i.e., it investigates the use of explanations in the specific situation where a decision
maker uses a KBS as a decision support tool to support judgmental decision making under conditions of uncertainty. While KBS are used in various roles, e.g., as decision takers, intelligent assistants, etc., this research focuses on the decision support role of KBS. Thus, KBS explanations are viewed as decision aids that are provided to enhance the quality of decision making in judgmental situations. As well, of the various types of decision situations that exist, e.g., those ranging from unstructured to structured, those with varying numbers of alternatives and/or attributes, those with varying levels of uncertainty, etc., this study focuses on, and is primarily relevant to, judgmental decision making situations under conditions of uncertainty.

The study also takes a cognitive learning approach to KBS explanations. It focuses specifically on the learning that takes place when a decision maker uses KBS explanations, by assuming that users undergo a learning experience when they use a KBS-type decision aid. Unlike conventional DSS which generally provide decision makers with information and tools to better analyze a decision problem, KBS that are used as decision aids provide decision makers with specific advice or recommendations. Hollnagel [1987] argues that, if users are to remain responsible for the decisions made, they will not accept advice and recommendations based on reasoning they do not understand. Thus, not only must KBS provide such advice but they must also ensure that the user learns about the basis for the advice. KBS explanations have this critical role of ensuring that users learn about or develop an understanding of the functioning of the KBS. This study focuses on this learning role of explanations. Thus, it heeds Wensley's [1989, p. 251] call for more research into the design of systems to assist the learning process of individuals, by focusing on the learning effects of the use of decision aids.
1.3 Research Questions

By taking a cognitive learning theory based approach to the provision of KBS explanations, this study has the goal of addressing three fundamental research questions:

1) To what extent are explanations used in judgmental decision-making situations supported by the use of a KBS?

2) What factors influence the use of KBS explanations? and

3) Does the use of explanations benefit KBS users in any way?

The objective of the first research question is to uncover the amount of explanations provided that are used. Unlike situations where the KBS is used as a training tool, there is reason to believe that in decision making situations, decision makers will not utilize all the explanations that are provided to them. Considering that the relevance of KBS explanations to such decision situations has not been empirically demonstrated to-date, the study will attempt to provide evidence of the extent to which explanations are used in such situations.

With respect to the second research question, the study will specifically investigate the influence of four factors. First, it will test the influence of the provision of explanations as "feedforward" and "feedback". As will be discussed in Chapter 2, these are two concepts that have been identified, by research based on the cognitive feedback paradigm, as being the primary cognitive learning operators that foster learning in judgmental situations. Second, the influence of user expertise will be investigated. Prior studies of KBS explanations and theories of skill acquisition suggest that there will be expert-novices differences in the use of explanations. Third, the influence of three generic types of explanations that are currently implemented in KBS will be
analyzed. These include Why explanations that justify a KBS state or action by revealing the underlying reasons that are based on causal models, How explanations that describe or trace the contents and reasoning of a KBS, and Strategic explanations that clarify overall problem-solving strategy and meta-knowledge. Fourth, the study will examine the relationship between the level of user agreement with recommendations of a KBS and the use of explanations. While prior research has shown that this is a significant relationship, the precise nature of the relationship has not been studied yet.

The third research question is motivated by the desire to understand the benefits that accrue to users of KBS explanations. The effort and cost incurred in the development of an explanation facility can only be justified if there are significant benefits accruing from its use. This question has not been investigated to-date, although some researchers have observed that "the effect of explanations on performance is methodologically more difficult to investigate, but is certainly more relevant" [Ye, 1990, p.164]. While Chapter 3 identifies various behavioral, perceptual, learning, and judgmental effects of the use of explanations, this study will focus on the effect of the use of explanations on the accuracy of judgments and on user perceptions of usefulness.

1.4 Organization of the Dissertation

The dissertation is organised as follows. Chapter 2 takes a cognitive learning approach to understanding the reasons as to why explanations are needed in judgmental decision making situations involving the use of a KBS. By using the feedforward and feedback concepts of cognitive learning, it develops a theoretical model for conceptualizing the provision of KBS explanations. As well, it analyzes the roles of feedforward and feedback within the context of the ACT theory of
cognitive skill acquisition [Anderson, 1982] and Hogarth's [1981] model of expert judgment. Based on the theoretical model developed in Chapter 2, Chapter 3 classifies the various types of explanations found in current applications of KBS. Additionally, it presents a two-part framework for investigating the use of KBS explanations that identifies both the factors that influence the explanation selection behavior of KBS users, as well as the potential effects of the use of the explanations. It also presents a review of prior studies that empirically investigated issues related to the use of KBS explanations, and proposes specific hypotheses that are empirically tested in this study. Chapter 4 describes the various considerations involved in the selection of the task domain, as well as the development and validation of an experimental KBS that is used to test the hypotheses. Chapter 5 outlines the research design and operationalization details of the experiment conducted, while Chapter 6 presents the results of the statistical analysis of the data collected. Finally, Chapter 7 discusses the implications of the findings, limitations of the research, its contributions, as well as directions for future research.
CHAPTER 2: A COGNITIVE LEARNING APPROACH TO KNOWLEDGE-BASED SYSTEM EXPLANATIONS

2.0 Introduction

The study utilizes a cognitive learning theory based approach for conceptualizing knowledge-based system (KBS) explanations. Concepts related to the two cognitive learning operators of feedforward and feedback are used to characterize the provision of KBS explanations. The next section presents the reasons for taking a cognitive learning perspective to the study of KBS explanations and distinguishes between two different situations in which learning takes place. The following section details the lens model [Brunswik, 1956] and the cognitive feedback paradigm [Balzer, Doherty, and O’Connor, 1989] that provide a basis for understanding the nature of learning in judgmental situations under uncertainty. Section 2.3 utilizes the two cognitive learning operators of the cognitive feedback paradigm --- feedforward and cognitive feedback, to conceptualize strategies for the provision of knowledge-based system explanations. Section 2.4 discusses the role of these strategies in both the acquisition and application of domain expertise in judgmental situations. This is done in the context of Anderson’s [1982] ACT Theory for the acquisition of domain expertise, and Hogarth’s [1987] model of the judgmental process for the application of expertise.

2.1 Explanations and Cognitive Learning

Ever since explanations were introduced as part of the interface of MYCIN [Scott, Clancey, Davis, and Shortliffe, 1977], it has come to be taken for granted by the artificial intelligence
community that all KBS should provide explanations [Buchanan and Shortliffe, 1984]. However, although there exists a substantial amount of literature on the nature and structure of explanation in the philosophy of science [Toulmin, 1958; Hempel, 1965, Achinstein, 1971], the provision of KBS explanations has not been theoretically or empirically studied thoroughly to date. There exist no theories that answer fundamental questions such as: 1) why should KBS provide explanations, or 2) what benefits are there for users of KBS to make use of explanations that are provided? Considering that the general aim of cognitive science and artificial intelligence, particularly the study of expertise and knowledge-based systems, is to mimic human behavior and performance [Davis and Lenat, 1983; Hayes-Roth, 1983; Buchanan and Shortliffe, 1984], it is imperative that human explanation should serve as a model for the design of KBS explanation. Unfortunately however, the study of human explanation, as a psychological or behavioral phenomenon, is itself poorly understood and has not been the focus of much research. The few exceptions, all of which were motivated by the advent of KBS explanation facilities, are Coombs and Alty [1980], Goguen, Weiner, and Linde [1983], and Paris [1987]. In view of this situation, Ye [1990] has proposed a model based on user models of the task domain as a basis for the study of KBS explanation. Prior to the assessment and discussion of what would constitute an appropriate theoretical framework for KBS explanations, it is important to assess the reasons why explanations are used.

2.1.1 Reasons for the Provision of Explanations

Considering that MYCIN introduced and set the standard for the explanation facility being an integral component of the concept of a knowledge-based system, it is important to first comprehend the original motivations of MYCIN's designers. Buchanan and Shortliffe [1979] incorporated explanations in MYCIN because they felt that providing reasonable explanations, in
addition to good advice, was critical for the system to be "acceptable to users." Underlying this concept of user acceptance was their belief that for the system to be acceptable it had to be "understood by clients." Clancey [1985, p. 216], notes that this approach was in stark contrast to common Bayesian programs, which did not capture nor explain an expert's reasoning, and were therefore not easily understood by their users. He further notes that using MYCIN for teaching medical students was consistent with its design goals that its explanations had to be "educational" to naive users. While Buchanan, Shortliffe, and Clancey have not precisely defined what they meant by being "understood by clients" or "educational to users", it is quite clear that MYCIN's explanation facility was incorporated primarily because they saw a "teaching" role for the KBS. The explanations were provided so that KBS users could learn from the use of the system, and it was believed that this could then somehow translate into user acceptance of the system.

This "teaching" role of KBS explanations is exemplified by the close relationship between the concepts of explaining and learning. Explaining is defined as making clear what is not understood, while learning involves gaining an understanding of a skill or a task, etc. [Clancey, 1985]. Thus, explaining a rule from the teacher's perspective is equivalent to understanding it from a learner's perspective. Hayes and Reddy [1983] provide further support for this dual teaching/learning role of explanations by arguing that humans explain for three reasons. First, explanations are given to clarify particular intentions. For example, clarifications are given when learners are unsure about why particular information is being asked for or a specific analysis is being performed. Second, explanations are given to teach or instruct a learner. Abu-Hakima and Oppacher [1990] argue that for this, it is necessary for the explainer to judge the level of knowledge and understanding possessed by the learner and to construct an explanation to fit that level. Third,
explaining is used to convince learners. For this, sound arguments need to be provided that yield supporting information as to why a particular piece of information is required and how a particular hypothesis is true or why competing hypotheses are false. Goguen, Weiner, and Linde [1983] further identify that naturally occurring explanations foster understanding by providing justifications by giving reasons, giving examples, and eliminating alternatives.

2.1.2 The Learning Versus Working Conflict

Given that explanations are provided primarily for the purposes of fostering understanding or learning, it is important to separate two distinct learning situations in which KBS explanations can be used. First, there is the situation where the only objective is to learn or to gain an understanding. This can be termed the instructional situation, for example when a KBS is used for training purposes. The second situation is where there are other, and usually more important, performance objectives besides the gaining of a better understanding. This can be termed the working situation, for example when a KBS is used for problem-solving or to make particular judgments or decisions. In such situations, the use of explanations to foster an improved understanding of the KBS or its domain is just as important as in the instructional situation. However, it can be expected that the use of explanations will be significantly different. Rational users will only use those explanations that they believe will, by improving their understanding, have a direct impact on their performance objectives. This highlights a critical, implicit assumption that underlies the provision of KBS explanations in all non-instructional situations and that also explains the incorporation of explanations in MYCIN for the purposes of making it "understandable and educational". This is the assumption that the learning that occurs inevitably in working situations will lead to improved performance. In the use of a KBS, explanations are the primary means by
which such learning is facilitated.

A primary characteristic of working situations that has a direct bearing on the use of KBS explanations is termed the learning versus working conflict [Carroll and McKendree, 1987]. It can be described as follows. Users want to use a KBS and its explanations because they want to get some task accomplished. This gives them a focus for their interaction with the KBS and increases the likelihood of their receiving concrete reinforcement from their use of the system. However, this same pragmatism, or focus on task accomplishment, also makes them unwilling to spend much time learning the KBS and its domain on its own terms. After all, to consult on-line, self-instructional explanations is for a time to cease working effectively. There is therefore a conflict between learning and working that is inherent in the use of explanations in working situations. This conflict often leads novice users to try and skip learning altogether by relying completely on the KBS’s conclusions without really understanding them. It also causes more experienced users to stagnate in terms of domain expertise. When situations occur that are more effectively described by new explanations, they are more likely to stick to explanations they already know, regardless of their efficacy in terms of explaining new situations. Thus, these tradeoffs between actual problem-solving and using explanations to improve performance through learning, can have the potential effect of undermining the motivation required to learn and to improve users’ knowledge and understanding of a domain. This motivational "cost" of learning can however be reduced through the design of better explanation facilities and interfaces. These will mitigate the learning versus working conflict by better integrating the cost of learning with the actual use of the KBS for performance. For this, it is imperative that the design of KBS explanations be based on a sound understanding of the learning that occurs in working situations. This is necessary if we are to overcome the trouble
users have in learning about the KBS/domain, and to avoid having their knowledge and understanding of the KBS/domain stagnate at the current level. These can be characterized as the "deskilling" effect of the use of KBS.

2.2 Explanations As Cognitive Feedback Within the Lens Model

While there are various theories of learning for instructional situations, such as cybernetic theory [Novak, 1977], assimilation theory [Ausubel, 1963], conversation theory [Pask, 1976], and ACT theory [Anderson, 1982], they shed little light on the learning that takes place in working situations, largely because they fail to consider the learning versus working conflict described in the last section. However, research based on the cognitive feedback (CFB) paradigm [for a summary see Balzer, Doherty, and O'Connor, 1989] that was developed within the framework of the lens model [Brunswik, 1956], is relevant to learning in working situations. While this work has focused on the comparative efficacy of concepts such as outcome feedback, cognitive feedback, and feedforward on the accuracy of judgmental decision-making under conditions of uncertainty, it has also been identified as being "central to the psychology of learning under uncertainty," [Balzer, Doherty, and O'Connor, 1989, pp. 410]. Much of this research has used judgmental accuracy as a surrogate for the measurement of learning in a variety of multiple cue probabilistic learning (MCPL) tasks [for reviews see Castellan, 1977, and Slovic, Fischhoff and Lichtenstein, 1977].

2.2.1 KBS Explanations Within The Lens Model

Brunswik [1952] proposed the lens model, that is depicted in Figure 2.1, as a general model of human behavior in uncertain situations. He argued that in most decision-making situations, there is a sharp distinction between the person making the judgment and the environment. Judgments
about events or objects in the task environment must be made by decision-makers in the absence of direct contact with the particular events or objects. For example, most prospective purchasers of a particular stock have to make their judgments and investment decisions without being in direct contact with the particular firm that is represented by the stock. This separation of the judge from the object or event being judged means that decision-making has to be based on a set of imperfect cues or "lenses" through which the judge views the object or event. These are imperfect in the sense that they are not perfect representations or predictors of the particular object or event. For example, the prospective investor relies upon available financial information such as stock prices, price-earning ratios, net sales over time, capital structure ratios, etc. as "lenses" thorough which the firm is understood. The relationships (termed $R_e$) between these financial indices or cues and the firm
represented by the stock (the object) are at best imperfect or probabilistic, thus the judgments have
to be made in conditions of "uncertainty". As well, there is a second set of probabilistic
relationships in the model. Considering that the various cues comprise a set of related yet different
indicators, the relationships between these cues (termed G) are in themselves probabilistic or
uncertain. For example, stock prices will contain information that will be redundant with that
provided by the price-earnings ratios while the net sales over time may contain completely different
information. As well, while for some industries there may be a positive relationship between price-
earning ratios and capital structure ratios, in others it may be the reverse. There is also a third set
of uncertain relationships in the model --- that between the cues and the judge (termed R_e). For
example, cues, such as financial ratios, will be perceived and used differently by different judges
as well as by the same judge at different points in time or under different circumstances. Thus, the
relative reliance on different cues can be affected by human cognitive factors such as learning,
fatigue, individual differences, etc.

The lens model also suggests that accurate judgment or "achievement", which can be
represented by the strength of the correlation between the objects/events and the judgments made
by the judge, is a function of the three uncertain relationships. The more knowledge or
understanding possessed by a decision-maker about these relationships the better will be the
decisional performance. The model can be summarized in Libby's [1981] simplification of the lens
model regression equation that was developed by Hammond, Hursh, and Todd [1964], as presented
in Figure 2.2. The equation states that judgmental performance or achievement (r_e) is a function of
three variables G, R_e, and R_s. G represents the set of probabilistic relationships between the various
cues or "lenses". The more knowledge possessed by the decision-maker about the correct weightings
\[ r_a = Fn \{ G, R_e, R_s \} \]

**Legend:**
- \( r_a \) = achievement
- \( G \) = accuracy of the cue weighting
- \( R_e \) = predictive ability of the cue set, and
- \( R_s \) = predictability of the individual (consistency)

**Figure 2.2: Lens Model Equation**

between the cues, the better will be judgmental performance. \( R_e \) represents the set of relationships between the cues and the object or event in the environment being evaluated or judged. The amount of information or understanding possessed by a decision-maker about the predictability of the cues has a direct bearing on judgmental performance. \( R_s \) represents the uncertain relationship between the cues and the decision-maker. The greater the understanding that decision-makers possess about the strengths and weaknesses of their own perceptual and cognitive information processing in relation to the cues, the better will be judgmental performance. This is because such an understanding will enable the decision-makers to apply their knowledge with sufficient consistency and completeness. This is often termed cognitive consistency [Hammond and Summers, 1972].

The pivotal idea underlying the model is Brunswik’s assumption that the basic units of cognition, or knowing, are relations [Hammond, McCelland, and Mumpower, 1980]. In an uncertain judgment environment, learning about these different relations will be helpful for improving a decision-maker’s understanding of the judgment task and this is the key to improved judgmental performance. The lens model equation also precisely specifies how learning about these relations will lead to more accurate judgmental performance or achievement. These correspond to
the components of the lens model, i.e., the environment, the cues, and the judge. The model can therefore be restated as follows: "Achievement is a function of knowledge, calibration, and cognitive consistency." Knowledge relates to the understanding of the object or event in the task environment. Information can therefore be provided to make the judge more knowledgeable. Calibration relates to the understanding of the accuracy of the match between the cue weightings perceived by the judge and those that truly exist in the task environment. Information can therefore be provided that will make the judge more calibrated. Similarly, cognitive consistency which is the understanding of the judge's cognitive decision strategy can also be improved; information can be provided that will make the judge more consistent in the application of his or her strategy.

The lens model is not a theory of learning for instructional situations and does not offer any prescriptions as to how learning can be fostered in those situations. Rather, it is a model of the structure of judgmental problem-solving (working) situations and it specifies precisely the three types of relationships that decision-makers need to understand, have clarified, or learn about during such situations. If information about these relationships is provided to decision-makers during problem-solving it will lead to improved judgmental performance. The challenge to developers of decision aids is to determine precisely how and when this information should be provided, during a problem-solving session involving the use of such decision aids, to maximize the understanding of the user. In the case of a KBS being used as a decision aid in a working situation, the explanation facility can make these three kinds of information available to users. As an example, consider the case of a KBS that performs financial statement analysis. First, explanations that clarify why a particular ratio (cue), such as the debt-equity ratio, is related to an aspect of the firm's financial position, e.g. capital structure, will represent the provision of $R_e$ information, i.e., it will facilitate
the understanding of the relationship between the cue and the environment. Second, another set of explanations may explain how various liquidity ratios, such as the current ratio, inventory turnover, day sales in receivables, etc., are combined to evaluate the various sub-aspects of liquidity analysis. This represents the provision of G information, and it will facilitate the understanding of the relationships between the various cues used to represent liquidity. Third, by keeping track of the ratios that are used by users in performing a particular analysis and matching these usage patterns to predefined profiles of typical users, the explanation facility may provide R explanations by revealing information about the cues that are most important to such users. These will facilitate the learning of the relationships between the cues and the judge.

In summary, the lens model provides guidelines as to three specific types of information that can be provided as explanations to foster learning in judgmental problem-solving (working) situations. A theoretical basis for exactly how and when this explanatory information can be provided and prescriptions as to the relative efficacies of the three kinds of information is provided by the cognitive feedback paradigm that has evolved out of the lens model.

2.2.2 A Cognitive Learning Basis for the Provision of KBS Explanations

Research into cognitive learning operators has been motivated by the desire to provide a psychological answer to the following question: "How might persons learn to improve the accuracy of their judgments?" [Balzer, Doherty, and O'Connor, 1989, p. 10]. To a great extent, this question has arisen out of concerns such as people have difficulty inferring environmental relationships from unaided experience [Brehmer, 1980], and more generally, people are limited in their ability to process information in uncertain environments [Nisbett and Ross, 1980; Kahneman, Slovic and
Tversky, 1982]. The traditional answer to this question has been "provide knowledge of results" or what is commonly termed as the feedback cognitive learning operator. This represents an extension, to the learning of cognitive skills, of the critical role that feedback has traditionally played as a means of reinforcement in the learning of physical skills, e.g., the notion of reinforcement schedules in Skinner's philosophy of radical behaviorism and Pavlov's notion of classical conditioning in the learning of reflexes or respondent behaviors [Bower, 1981]. These early conceptualizations of feedback were oriented towards outcome or performance reporting for purposes of facilitating control. For example, Annett [1969] asserts that "at its most basic level feedback is information received by an individual about his or her past behaviour." It provides an evaluation of the correctness, accuracy or adequacy of the individual's response. This reflects the influence of cybernetic theorists [e.g., Wiener, 1948] who introduced the concept of the feedback loop to the behavioral sciences. Such feedback loops are considered to be central to the ability of self-regulating systems to correct deviant behaviour in reaching stable states. As the primary focus of this feedback was on reporting the outcomes of actions, it has generally come to be termed outcome feedback (OFB). It has been asserted that outcome feedback enables individuals to understand and improve their judgments, improve their expertise in judgment tasks, and reduce commitment to incorrect judgment strategies [Hogarth, 1981]. As well, it has often been provided to people on the assumption that it will lead to improved decisions.

However, various reviews of studies that have used the multiple-cue probability learning task paradigm, to investigate the effects of outcome feedback on judgmental decision-making under uncertainty, reveal that outcome feedback is generally ineffective in fostering learning and improved judgmental performance [Hammond, Stewart, Brehmer and Steinmann, 1975; Brehmer, 1980;
Hoffman, Earle, and Slovic, 1981]. The consensus is that, with the exception of simple tasks such as those involving two-cue linear function relationships, individuals do not learn from OFB in complex, uncertain tasks. On the contrary, there is evidence that OFB was detrimental to cognitive learning in certain tasks [Hammond, Summers, and Deane, 1973]. There are several reasons that explain this phenomenon. First, when the relationship between cues and criterion is probabilistic, the erroneous information (noise) in outcome feedback results in the lack of cognitive control ($R_e$, in the lens model equation) [Libby, 1981, p. 29]. The constant adjustments made by learners to the random error variances in outcome feedback lead to them not being able to apply their own knowledge of judgment strategies in a consistent manner. Second, outcome feedback fails to provide sufficient task information to enable decision-makers to form a suitable model of the environment [Brehmer, 1987; Sterman, 1989]. Third, in the case of dynamic decision-making situations, it does not allow decision-makers to correctly perceive key relationships and significant changes in the system [Brehmer, 1990; Sengupta and Abdel-Hamid, 1991]. Additionally, Hammond [1971] has also demonstrated that some complex tasks may not be learned at all when only outcome feedback is provided.

Considering that multiple-cue probability learning tasks are similar to more complex diagnostic tasks, in the sense that both require individuals to make holistic judgments based on a number of multiple-cue decision profiles in uncertain conditions, these results for OFB have serious implications for KBS. Most importantly, they provide a theoretical basis for the belief held by the KBS community, and by the original developers of MYCIN, that KBS must provide other output, such as explanations, in addition to outcome recommendations. This is especially critical when they used as decision aids. In relation to the deskilling effect of the learning versus working conflict that
was discussed in Section 2.1, it implies that if regular users of KBS do not want their domain expertise to stagnate at a mediocre level, they must use explanatory information provided by the KBS to foster increased learning and not just rely on the system’s recommendations. This lends theoretical support to Southwick’s [1991, p.14] assertion that "we have to move from an expert system that produces a solution as a result, to a consultation system where the entire consultation is the result. Explanation has to progress from the verification of an expert system’s solution, to being the solution itself."

2.2.3 The Feedforward and Cognitive Feedback Learning Operators of the Cognitive Feedback Paradigm

The deficiencies of outcome feedback as a cognitive learning operator in judgmental decision-making have led to a search for alternatives to it. This search has resulted in a widening of the feedback concept. Subsequent work has revealed another dimension of feedback. Ilgen et al. [1979] refer to the "information value" of feedback which they say depends on the incremental increase in knowledge about performance that the feedback provides the recipient. This is consistent with the literature on the decision theoretic value of information [Hilton, 1981] and extends the earlier definition of feedback from the notion of "accuracy of performance for cybernetic control" to "knowledge about performance." As well, it explicitly recognizes the role of cognitive learning in improving judgmental performance in working situations. The two distinct types of feedback can therefore be recognized as providing either 1) outcome variance information for calibrating performance (OFB) and 2) information increasing the understanding and comprehension of the recipient. The study of the latter has come to be termed the cognitive feedback paradigm [Todd and Hammond, 1965] and the lens model [Brunswik, 1956] has been used to understand the specific
types of information that, by increasing the understanding of decision-makers, improves the accuracy of judgmental performance. This paradigm proposes the two alternative cognitive learning operators of cognitive feedback (CFB) and feedforward (FF) as alternatives to outcome feedback. Theoretical support for these originate in Bjorkman's [1972] analysis of feedforward and cognitive feedback in the study of cognitive learning processes. He identified them as the being the two critical "cognitive learning operators" that facilitate improved understanding and comprehension. As well, he argued that while both have the same function, namely to reduce uncertainty about the task, there are also critical distinctions between them.

2.2.3.1 Components of Cognitive Feedback and Feedforward

The lens model equation, discussed in Section 2.2.1, specified the three kinds of information that need to be provided to decision-makers to help them improve judgmental performance by increasing their understanding of the judgmental task. The cognitive feedback paradigm takes these to be the precise components of both the cognitive feedback and feedforward learning operators. They are conceptualized as being information provided to the decision-maker about (a) the relations in the decision environment, (b) relations perceived by the decision-maker about that environment, and (c) relations between the environment and the decision-makers's perceptions [Balzer et al, 1989]. Such information seeks to improve decision making by enhancing a decision maker's understanding of the task structure, his or her cognitive system, and the fit between the two [Hammond, Stewart, Brehmer and Steinmann, 1975]. While these correspond respectively to the R_e, R, and G types of information of the lens model equation, in the language of the cognitive feedback paradigm, these are termed task information (TI), cognitive information (CI), and functional validity information (FVI), respectively.
Numerous studies have compared the relative value of the three types of information that can be provided as feedforward or cognitive feedback [see Balzer, Doherty, and O’Connor, 1989 for an extensive summary]. The results indicate that task information (TI) is the most effective amongst them in fostering the learning of accurate judgmental performance [Newton, 1965; Adelman, 1981; Hoffman, et al, 1981]. The provision of cognitive information (CI) has little effect both in itself or as an addition to task information [Schmitt et al, 1976]. The unique effects of functional validity information (FVI), however, have not yet been adequately studied for any consensus to emerge [Balzer, et al, 1989]. These results have serious implications for the provision of KBS explanations. They suggest that task information should be given the greatest priority for inclusion in explanation facilities. The explanations provided by MYCIN, as well as by most other currently implemented KBS, do focus on the provision of task information. As well, the finding that CI is ineffective in fostering learning suggests that intelligent explanation facilities that provide customized explanations to users based on user models of the task [Rich, 1983; Ye, 1990; Southwick, 1991, p. 8], are not likely to be effective. However, some researchers argue that while CI may be ineffective in fostering learning in judgmental situations, its value in limiting the dysfunctional effects of poor cognitive control increases as the task environment becomes richer and more complex [Sengupta and Te’eni, 1991].

2.2.3.2 Differences Between Cognitive Feedback and Feedforward

While TI, CI, and FVI can be provided as part of both the feedforward and cognitive feedback learning operators, there are critical distinctions between the two. Cognitive feedback generally focuses on providing TI, CI, and FVI information that clarifies case specific outcome feedback, i.e., it uses outcome feedback (OFB) as the starting reference point for improving the
decision-maker’s understanding of the task. Feedforward, on the other hand, is not case specific and is generally unrelated to the outcomes of the specific case (OFB) being considered [Bjorkman, 1972]. It is for this reason that the terminology of the CFB paradigm while carefully distinguishing between outcome feedback and cognitive feedback, does not decompose feedforward information in a similar fashion. All feedforward information, is by definition, "cognitive feedforward", i.e., it has the objective of improving understanding of the task by providing TI, CI, and FVI information to reduce task uncertainty. Bjorkman [1972] argues that knowledge learned through feedforward will be more accurate and consistent since it does not suffer from various errors and biases associated with the trial-by-trial transmission of cognitive feedback information through outcome feedback.

Another critical difference focuses on the temporal order in which they are provided. By definition, feedforward is always provided prior to task performance while feedback is always presented on the completion of the task and subsequent to the specific outcome feedback, to which it is associated, being provided [Bjorkman, 1972]. Largely focusing on this distinction, some researchers have chosen to operationalize feedforward as being training provided prior to task performance. For example, Malloy, Mitchell, and Gordon, [1987] provided subjects with a set of heuristics for effectively performing the task, and Sengupta and Abdel-Hamid [1991] used an hour-long training session on the Brook’s Law of project management. This temporal distinction between feedforward and cognitive feedback can be used to identify advantages of one over the other. Skinner’s [1968] argument that for "individuals to learn from explanatory information that is provided to them, they must be able to associate it with their actions," suggests that cognitive feedback will be superior to feedforward. Being provided just after the outcomes of an individual
action become known, it should be easier to associate and will therefore facilitate greater understanding of the task. Along these same lines, Anderson et al., [1989] assert that since cognitive feedback is provided just after outcome feedback, it eliminates the memory burden of holding all the information that is relevant to a whole range of possible outcomes that may result from a particular action. Being provided before task performance, information provided as feedforward adds to this memory burden. On the other hand, however, it can be argued that feedforward relieves the learner from a certain amount of cognitive strain as the information that is primed in memory during task performance will allow the learner to better understand the task requirements during problem-solving. This is supported by Bjorkman’s [1972] assertion that feedforward in effect reduces cognitive load on a subject because it provides, prior to task performance, a large amount of the information that the subject would otherwise have to infer from experience, i.e., outcome feedback.

A third distinction between feedforward and cognitive feedback is that they focus on different sets of cues. Generally, feedforward is information that relates to the cues that serve as input variables in a task, while feedback is information that relates to the outcomes of the task that is performed. To a large extent, this distinction arises from the fact that cognitive feedback is outcome-specific while feedforward is unrelated to outcomes and is provided at the start of task performance [Bjorkman, 1972]. Cognitive feedback uses the clarification of case-specific outcome cues (OFB) as a starting point and provides information that traces the reasoning backwards to the input cues. Feedforward information on the other hand focuses on the clarification of the input cues and traces the reasoning forwards to the outcome cues.
Thus, while feedforward and cognitive feedback are distinctive concepts, they are by no means mutually exclusive. Rather, they have a compensatory relationship to each other in relation to fostering learning in working situations [Bjorkman, 1972]. There is less to gain from feedback explanations when feedforward explanations are clear and comprehensive and vice versa. This is not unlike the tradeoff between the concepts of learning-by-being-told (feedforward) and learning-by-doing (feedback) in skill acquisition. Bjorkman [1972, pp. 156] further notes that "there is at present an almost complete lack of data on the interplay between feedforward and feedback in producing knowledge (learning) and forming policies (action)."

2.2.3.3 Effectiveness of Feedforward and Cognitive Feedback In Fostering Learning

A significantly large number of studies using a wide variety of tasks have evaluated the efficacy of cognitive feedback in terms of how effectively subjects learn to improve the accuracy of judgmental performance. Balzer, Doherty, and O'Connor [1989] provide an extensive review of them and note that the bulk of these studies have used: (a) the outcome feedback condition as the control group, and (b) the lens model measures of achievement (judgment accuracy), knowledge, and cognitive consistency as dependent measures. There was considerable evidence that cognitive feedback, especially in the form of task information (TI), had a significant effect on such learning [Steinmann, 1974; Schmitt et al, 1976; Neville, 1978; Hoffman et al. 1981; and Adelman, 1981]. Generally, both knowledge and cognitive consistency improved as a result of the use of cognitive feedback and led to improvements in the accuracy of judgments. As well, Lindell [1976] found a significant cognitive feedback by task complexity interaction --- as task complexity increased, cognitive feedback led to significant improvements in achievement, knowledge and cognitive consistency. These results from psychological studies that used generic multiple-cue probabilistic
learning tasks, have also been confirmed in what Libby [1981, p. 30] terms as "meaningful tasks," i.e., tasks that incorporate significant contextual empirical referents, e.g., Harrell [1977]; Regel, [1985]; Luckett & Eggleton [1991]. As well, Kessler and Ashton [1981] found a significant effect for task properties (TI) cognitive feedback on the learning of the financial analysis task which Libby [1981, p. 131] considers "a meaningful task where both theoretical and empirical relationships exist." Balke et al, [1973] had pairs of management and union negotiators make (a) judgment ratings of the acceptability of hypothetical labour contracts, and (b) predictions of their counterparts' ratings, before and after the provision of cognitive feedback. Their results also confirm the effectiveness of cognitive feedback. Interestingly, the negotiators who received cognitive feedback reported that it gave them insights into their own and their counterparts' judgmental processes and went on to suggest that it would be valuable to receive such information at the start of the negotiation process (feedforward).

There is also evidence of the effectiveness of feedforward [Steinmann, 1976; Galbraith, 1984; Sengupta and Abdel-Hamid, 1991]. It is however less conclusive, largely because it has been studied to a lesser extent. This is because it is a much more difficult construct to operationalize than cognitive feedback. Cognitive feedback which seeks to explain the outcomes of a specific problem-solving case is by definition more focused and therefore easier to operationalize, both in the context of the multiple-cue probability learning tasks that have been used in laboratory settings and the more realistic "meaningful tasks". As a result, feedforward has been studied by only a handful of studies that attempted to directly compare the relative efficacy of feedforward to that of cognitive feedback. Of the three types of information (TI, CI, and FVI), all these studies used task information to operationalize both feedforward and cognitive feedback. Using multiple-cue probability learning
tasks, both Galbraith [1984] and Steinmann [1976] found that feedforward was just as effective as cognitive feedback in fostering higher achievement (the learning of judgmental accuracy) and knowledge. For cognitive consistency, however, both studies found that feedforward was superior to cognitive feedback, in that it allowed subjects to better understand and control the execution of their problem-solving strategies. Steinmann [1976] also reported that feedforward was just as effective as cognitive feedback in simple as well as complex tasks. In reviewing these studies, Balzer et al. [1989, p. 423] has observed that because feedforward, which is provided prior to task performance, is just as effective as cognitive feedback, it will place a ceiling on the potential improvement that can be expected from the additional provision of cognitive feedback. Along these same lines, Steinmann [1976] suggests that future studies should attempt to "ascertain the point at which cognitive feedback is required in addition to feedforward." However, as neither of these studies manipulated the absence or presence of feedforward, but rather focused on comparing it to cognitive feedback, the unique contribution of feedforward cannot be separated. Studies conducted using a wide variety of realistic tasks have demonstrated that feedforward, operationalized as the pre-task provision of problem-solving heuristics or training sessions, has a significant effect on learning and is more effective than outcome feedback [Cats-Baril and Huber, 1987; Malloy et al, 1987; Robertson, 1987]. However, Sengupta and Abdel-Hamid [1991] found that it was less effective than cognitive feedback in the context of a software project management task.

In summary, there is evidence that the provision of feedforward and cognitive feedback is effective in fostering learning in working situations, especially in comparison to outcome feedback. However, there is a lesser understanding of their relative efficacies and the interplay between them in these situations.
2.2.4 The Cognitive Feedback Paradigm and the Provision of KBS Explanations

The merger of lens model judgment research and the psychological analysis of cognitive learning operators has led to the term CFB paradigm "achieving the status of a technical term in the literature" [Balzer, Doherty, and O'Connor, 1989]. It has been extensively studied in numerous laboratory and applied judgment situations and its concepts have been borrowed by various other domains, e.g., the "outcome feedback" (OFB) and "cognitive feedback" (CFB) concepts of Social Judgment Theory [see Hammond, McCelland and Mumpower, 1980] which explains how individual decision-makers take into account the outcomes of decisions made by others.

In the mainstream management decision making literature, the distinction between outcome and cognitive feedback and their relationship to learning is also understood and recognized. For example, Argyris's [1982] characterization of double-loop learning is related to the notion of incorporating cognitive feedback loops for increasing management's understanding and comprehension of a decision situation. Within the context of decision support systems (DSS), however, it has had a lesser impact. For example, Te’eni [1990] asserts that feedback is information that 1) is provided by the DSS to the user, 2) concerns the current or previous decision-making process, decision, or outcome, and 3) is designed to help the user adjust the decision-making process to better accomplish the decision task. This definition focuses primarily on outcome feedback for streamlining decision making performance, and fails to recognize the cognitive learning effects of feedback. DSS researchers are now beginning to study its implications. Examples of these include the impact of alternative feedback strategies in dynamic decision making [Sengupta and Abdel-Hamid, 1991] and the role of cognitive feedback in improving control and convergence in group decision support systems [Sengupta and Te’eni, 1991].
It can be argued that the cognitive feedback paradigm is especially relevant to the development of KBS. This is because KBS go beyond the provision of outcome feedback, in the form of intermediate and final recommendations, to provide explanations. The provision of explanations, such as the Why, How, What, and Strategic explanations [Wick and Slagle, 1989], represents the provision of cognitive feedback. As was discussed in Section 2.1 the provision of KBS explanations has the objective of increasing user understanding and comprehension in working situations. This is also precisely the objective for the provision of feedforward and cognitive feedback in judgmental decision-making situations and the reason why they have been so extensively studied. The distinction between outcome feedback and cognitive feedback is also evident in the case of KBS. For example, consider the case of a KBS that provides advice as to the selection or rejection of loan applications. The specific advice offered by the system is outcome feedback. Any other information provided to explain the KBS's reasoning or the task domain is either feedforward or cognitive feedback, e.g., how the outcome was reached, what are its implications, and why it was necessary to consider certain input variables or sub-analyses. For these reasons, this study uses the two cognitive learning operators of the cognitive feedback paradigm to conceptualize a theoretical basis for the manner in which KBS explanations can be provided. This feedforward and feedback model for the provision of KBS explanations is expounded in the next section.

2.3 Feedforward and Cognitive Feedback Strategies for the Provision of KBS Explanations

This section considers the role of feedforward and cognitive feedback as explanations that are provided within a model of the typical user-KBS interaction. Figure 2.3 provides a conceptualization of such an interaction. It can be viewed as an alternating series of two different kinds of stages. These are information exchanges where the user and the KBS exchange
information and \textbf{system operations} where the KBS "goes away" from the interaction to perform some analysis or function. Human-computer interface designers have generally focused on optimizing the information exchanges that take place. Other designers of hardware and software generally try to minimize the system's "going away to work" time as it represents a wasted or
inactive period from the user's perspective. As well, each information exchange involves a pairing of the system making a presentation and the user undertaking some action and vice versa. These are often respectively termed the presentation language and action language, in the study of human-computer interaction [Bennett, 1983, p. 45]. System presentations generally involve the KBS asking for input data or control instructions and displaying questions, explanations, user-action options, and system conclusions. User actions generally include initiating a consultation, providing domain facts or input data, requesting explanations, selecting options, and reading system presentations.

According to this conceptualization, explanation provision is just one aspect of the total user-KBS interaction. It represents an information exchange, rather than a system operation, with the user requesting an explanation and the KBS providing it. As well, based on Coombs and Alty's [1980] finding that human explanation seeking behavior is context-driven, it can be assumed that explanations that are requested or provided will usually relate to the particular aspect of the overall task that is currently being resolved by the KBS. The resolution of these sub-tasks is represented by the system operations in Figure 2.3. Therefore, explanations relating to a particular system operation can be provided at two junctures. They can be provided as part of the information exchange preceding the particular system operation or as part of the information exchange directly following its completion (see Figure 2.4). In the former case it can be termed feedforward explanation provision and in the latter case feedback explanation provision.

Considering the distinctions between the feedforward and cognitive feedback learning operators that were discussed in Section 2.2.3.2, there are three fundamental differences in feedforward and feedback explanation provision. First, feedforward explanations are not case
specific while feedback explanations are focused on case-specific outcomes. Second, feedforward explanations are made available prior to the KBS performing a particular system operation, while feedback explanations are provided subsequent to the system operation’s conclusions (outcome feedback) being displayed by the KBS. Third, feedforward explanations relate to the inputs used in the particular system operation, while feedback explanations focus on clarifying the outcomes of that system operation.

This cognitive learning conceptualization of the provision of KBS explanations means that KBS designers have a choice of three possible strategies that can be used to provide explanations in an effort to increase user understanding during the use of the KBS in working situations. These
explanation provision strategies are: 1) provide only feedforward explanations, 2) provide only feedback explanations, and 3) provide both feedforward and feedback explanations. As well, these three strategies are pertinent to all the various types of explanations that are currently provided by KBS, e.g., the Why, How, and Strategic explanations. Each of these explanations can be provided in both feedforward and feedback forms as part of the three strategies. However, it can be expected that for each type of explanation, one of the three explanation strategies will be more effective than the others in increasing user understanding and comprehension. This suggests that in working situations involving the use of a KBS, the specific nature and timing of explanation provision will directly influence the type of explanation that is selected for use by KBS users. This issue will be further pursued in the next chapter.

In summary, just as outcome feedback is the primary learning operator for the acquisition of physical skills, e.g., learning to ride a bicycle, cognitive feedback and feedforward explanations are the primary learning operators for learning during judgmental decision making involving the use of a KBS. While the literature is equivocal in terms of the comparative value of feedforward and cognitive feedback, there are reasons though to believe that one is more effective than the other at different stages of the cognitive skill acquisition process. For example, Steinmann [1976] found that more experienced judges used cognitive feedback to improve their judgments to a greater degree than did less experienced judges. Their comparative value can also be expected to be different during the various stages of the application or use of cognitive skill. These aspects are discussed in the next section.
2.4 The Role of Feedforward and Feedback In the Acquisition and Application of Expertise

This section attempts to understand the roles that feedforward and cognitive feedback explanations play at the various stages of the judgmental process. As well, it analyzes how their effectiveness varies in relation to the level of expertise that is possessed by decision makers.

2.4.1 Role of Feedforward and Feedback Explanations In Hogarth’s Model of Judgment (Cognitive Skill Application)

Explanatory information plays a central role in the acquisition and application of domain expertise in judgmental situations [Hogarth, 1981]. This is evident if one considers the different roles of feedforward and feedback explanations within a modified version of Hogarth’s [1987] model of judgment, that is presented in Figure 2.5. The model views judgmental decision making as being the application of cognitive skill or expertise, and views it as taking place within a system composed of three elements --- the decision maker, the task environment, and the actions that result from judgment and that can subsequently affect both the decision maker and the task environment.

At the cognitive level, the exercise of judgment that leads to behavioral action can be decomposed into three operations as depicted in the model. These are: 1) the acquisition of the expertise schema, 2) the retrieval and processing of the expertise, and 3) the judgment itself. This decomposition is similar to the computational theory of the mind [Marr, 1982] which treats the brain as an information processing system [Newell and Simon, 1972] and is consistent with Payne’s [1982, p.386] characterization of the decision making process as being composed of the three subprocesses of feedback/learning, information acquisition and information evaluation. Additionally, the exercise of judgment takes place within a system of two subsystems. First, there is the task
FIGURE 2.5:
Role of Explanations in the Use of Expertise
environment within which the decision maker makes the judgment. Second, there is the decision maker’s schema comprising declarative knowledge and problem solving strategies. This schema symbolizes the decision maker’s knowledge and beliefs concerning the task environment and his or her representation of it [Norman, 1983; Gentner and Stevens, 1983].

Feedforward and cognitive feedback explanations, together with outcome feedback, are critical to the carrying out of all the three operations --- acquisition, processing, and judgment. While the provision of cognitive feedback and feedforward explanations directly impact the individual’s schema or representation of expertise, the impact of the outcome feedback loop is limited to the task environment. Thus, feedforward and cognitive feedback explanations are the primary operators in the acquisition operation. These explanations directly provide schema shaping information to the decision maker. Otherwise, he or she would have to resort to inferring it indirectly by studying the impact of outcome feedback on the task environment. This would be an inefficient form of learning as a large number of trials or practice runs would be necessary. As well, such learning is impeded by a variety of cognitive biases, such as the availability heuristic, the representativeness heuristic, the law of small numbers, anchoring and adjustment, and illusory correlation [see Hogarth, 1987, pp. 166-170, and Kahneman, Slovic and Tversky, 1982, for complete reviews]. There is also no guarantee that the multiple outcome feedback loops will facilitate the acquisition of all the different kinds of knowledge that constitute the schema. This is especially the case for the acquisition of structural and strategic meta knowledge. It is argued that explanations provided in the form of feedforward or cognitive feedback will be much more efficient for acquiring these kinds of knowledge than such trial-by-trial learning. This highlights the critical role that the explanations play in the efficient and effective acquisition of expertise schemas.
During the schema processing operation, domain expertise is retrieved and applied to resolve problems. Here the three learning operators serve different but critical functions. The outcome feedback loop provides the data for 'pattern-matching' with knowledge stored in the person's schema. Feedforward and cognitive feedback explanations on the other hand, by fostering understanding and comprehension of the domain knowledge, facilitate efficient retrieval of expertise from long-term memory by directly reshaping the decision-maker's schema. This schema acts as a filtering and guiding aid in the retrieval and application of the relevant knowledge. The more developed the schema of the decision maker, the more likely it is that unguided traversal in long-term memory and exhaustive pattern-matching in short-term memory will be avoided during this schema processing operation. The strong priming effects of feedforward explanations, which are provided prior to task performance, will also facilitate schema processing during the judgmental process.

The output of the processing operation leads to some action being taken within the task environment. The consequences of this action impacts both the task environment and the decision maker's schema. Outcome feedback impacts the decision maker's expertise schema only indirectly, through observation of the calibration that goes on in the task environment as a result of the outcome feedback. This is inevitable as the task environment incorporates within itself the schema. Cognitive feedback explanations, on the other hand, do not provide the basis for a change in the task environment. Rather, by providing explanatory information which is relevant to and triggered by the outcome, they directly reshape the decision maker's schema through improved understanding. Similarly, feedforward explanations also shape the schema directly without impacting the task environment. Unlike cognitive feedback explanations, however, they are not triggered by the
outcome nor do they attempt to explain the relationship of the outcome to the schema. Rather, they are triggered directly from outside the task environment and are independent of any particular outcome.

2.4.2 Role of Feedforward and Feedback Explanations In the ACT Theory of Cognitive Skill Acquisition

In an investigation of human face-to-face advisory service interactions, Coombs and Alty [1980], found that the expertise level of advice-seekers was the major determinant of 1) the specific nature of such advisory interactions, and 2) the explanations and advice sought by users and provided by the experts. This finding suggests that significant expert-novice differences can therefore be expected in relation to the use and the effectiveness of feedforward and cognitive feedback explanations. It is therefore useful to consider the different roles of feedforward and feedback explanations within the context of the ACT theory of skill acquisition [Anderson, 1982]. This theory views the cognitive skill learning process, i.e., the acquisition of judgmental expertise, as a sequence of phases termed the declarative phase, the knowledge compilation phase and the procedural phase. Generally, individuals at the initial declarative phase can be regarded as novices in the particular task domain, while those at the final procedural phase as experts. Those at the intermediate knowledge-compilation phase can be considered to be apprentices.

During the **declarative phase**, the individual's initial performance involves the operation of general strategies utilizing declarative knowledge to guide performance. The individual learns from instruction and from the observation of the consequences of actions undertaken (outcome feedback). Feedforward explanations can serve to provide the individual with knowledge of the requisite
declarative knowledge and the initial problem-solving strategies at this phase. Feedforward explanations that clarify the reasons for the use of particular input data and the manner in which these input data is structured can be expected to be especially effective. As well, explanations that provide an understanding of the declarative knowledge relating to the various entities and input variables involved, e.g., definitional information, can be expected to be effective.

The knowledge compilation phase involves the conversion of the slow and conscious declarative knowledge interpretations into faster compiled procedures. This is where the individual begins to develop an overall conceptualization (model) of the domain expertise. This is where cognitive feedback explanations can be expected to be of greatest value to the individual from a learning perspective. For example, feedback explanations that explain how conclusions are reached and clarify the implications of these conclusions, will facilitate the acquisition of the efficient compiled procedures by fostering a greater understanding of the relevant knowledge structure and inference procedure. Other explanations that describe the meta-knowledge and control strategies used to solve the task, will expedite the acquisition of the overall model of the domain including the relationships between the various components and the ordering or structuring amongst them. These explanations will be just as effective irrespective of whether they are provided as cognitive feedback or feedforward.

At the final procedural phase, the associations between the components of the individual’s conceptual model become stronger and there is no longer the need to consciously initiate each separate action. The newly acquired models are refined and tuned through the process of over-practising and reinforcement to the point of automation and unconsciousness. This is often termed
the tacit dimension of expertise [Polanyi, 1966], and the individuals can now be considered to be true experts. Non-explanatory outcome feedback, which is central to the reinforcement process, is generally of critical value at this stage. Both feedforward and cognitive feedback explanations are of little value to the expert individuals as they will be performing instinctively and unconsciously and will have little time and patience for explanations both prior and subsequent to task performance. Therefore, it is reasonable to expect that individuals at this stage will use both feedforward and cognitive feedback explanations minimally. However, if these expert individuals are faced with anomalous system conclusions with which they disagree, they will largely utilize and benefit from the cognitive feedback explanations that clarify how the conclusions were reached. These explanations will act as recall triggers to the individual’s own expertise which would otherwise be unconscious and therefore unavailable. Feedforward explanations will not be effective at this stage.

In summary, this theory suggests that the level of expertise that an individual already possesses will exert a moderating influence on the effectiveness of the explanations that are provided as cognitive feedback or feedforward. For example, it is reasonable to expect that novices will make greater use of KBS explanations than experts. As well, they will benefit more from the use of feedforward explanations as compared to feedback explanations. As well, cognitive feedback explanations will generally be more effective in fostering greater understanding of the task in individuals who are apprentices or experts in the task domain.
2.5 Summary of the Chapter

This chapter heeds recent calls to researchers of decision support systems to pay more attention to the learning that is fostered by the use of such aids [Mackay and Elam, 1992], and tackles the fundamental question of why knowledge-based systems have to provide explanations. By distinguishing between the learning that occurs in instructional situations from that in working situations, it utilizes the lens model to identify the types of explanatory information that need to be provided to KBS users to foster learning in working situations. As well, it uses concepts relating to the three cognitive learning operators of the cognitive feedback paradigm --- outcome feedback, feedforward, and cognitive feedback, to provide a theoretical basis for 1) why KBS need to provide explanations in addition to advice, and 2) a model of explanation provision strategies for KBS. The next chapter considers the feedforward and feedback provision of explanations within a more comprehensive framework of factors that influence the use of KBS explanations and the effects of using these explanations.
CHAPTER 3: A FRAMEWORK FOR INVESTIGATING THE USE OF KNOWLEDGE BASED SYSTEM EXPLANATIONS AND RESEARCH HYPOTHESES

3.0 Introduction

This chapter presents the research hypotheses of the study within a two-part framework for evaluating aspects of the use of knowledge based system (KBS) explanations. Initially, Section 3.1 distinguishes between the selection and use of KBS explanations, and reviews the various types of explanations that are commonly provided by KBS explanation facilities. It also provides a review of past studies that have investigated the use of KBS explanations. The first part of the framework, which is presented in Section 3.2, identifies the various factors that influence both the amount and the types of KBS explanations that are used by KBS users. The second part comprises a model of the dependent variables that can be used for studying the effects of the use of KBS explanations, and is discussed in Section 3.3. Specific research hypotheses are developed in Section 3.4, by considering the feedforward and feedback explanation provision strategies that were described in Chapter 2, within the framework for studying the use of KBS explanations. These hypotheses are concerned with the following types of influences associated with the feedforward and feedback provision of KBS explanations: 1) To what extent are explanations utilized in judgmental decision-making situations involving the use of a KBS? 2) What factors influence the use of KBS explanations? and 3) Does the use of explanations empower KBS users in any way?
3.1 The Use of the Various Types of KBS Explanations

This section begins by defining what it meant by "the use of explanations" that are provided by a KBS. An understanding of this is critical to the design of explanation facilities that are usable and effective. Next, in Section 3.1.2, the various types of KBS explanations are presented, and considered in relation to the feedforward and feedback explanation provision strategies. Finally, Section 3.1.4 summarizes past studies that have investigated the use of KBS explanations.

3.1.1 Selection Versus Use of KBS Explanations

Explanation selection and explanation use are two distinct but related constructs. The former represents the explicit behavior of selecting and viewing explanations which is exhibited by users of KBS. Explanation use refers to the cognitive processing of explanatory information in judgmental decision making and problem solving using a KBS. It can reasonably be argued that only a subset of the explanatory information that is selected and viewed by KBS users is actually used in decision making. The cognitive processing of explanatory information is difficult to operationalize and measure, largely because it is visually unobservable. It therefore requires techniques for cognitive observation as against techniques for visual observation or physical measurement. While various process tracing techniques [Ericcson and Simon, 1984] provide reasonable approximations of the nature of such cognitive processing, they are less reliable in terms of providing estimates of the exact amount of processing that takes place. This is primarily because the completeness of the protocols that are collected is generally indeterminate [Nisbett and Ross, 1980]. For these reasons, it is proposed that the explanation selection behavior of KBS users, which is visually observable and physically measurable, be used as a measurable surrogate for the cognitive use of the information that is provided by such explanations. While this chapter focuses on the cognitive use of explanatory
information that is provided by a KBS, it uses the two terms interchangeably; however, the distinctions between them, and the deficiencies of selection as a surrogate for use, are recognized and understood.

3.1.2 Types of KBS Explanations

The Why and How explanations, which were first introduced in MYCIN [Shortliffe, 1976], remain the foundation of most explanation facilities found in current KBS applications and development shells. Attempts have been made to incorporate other forms of explanations. These include the Strategic, What, and What-If explanations. The Strategic class of explanations provide insight into meta-knowledge, especially the control objectives and overall problem solving strategies used by a system. For example, the NEOMYCIN system explicitly outlines problem solving strategies in its own knowledge base and makes them available for explanation [Hasling, Clancey and Rennels, 1984]. The What explanations are designed to give insight into object definitions or decision variables used by a system [Rubinoff, 1985]. They serve as responses to queries such as: "What do you mean by object or variable name"? The What explanation is significantly different from the What-If query facilities commonly found in decision support systems (DSS). These refer to the ability to re-run a consultation with changed model parameters. While such What-If facilities can be provided as part of the KBS interface, they are not viewed as being explanations per se, but rather as tools for sensitivity analysis. To be considered a distinct category of explanations, What-If has to be implemented as the direct and explicit provision of information about the sensitivity of decision variables to KBS users, instead of being a facility for performing sensitivity analysis.

Various classifications of the many types of explanations that should be provided by KBS
have been suggested [Neches, Swartout, and Moore, 1985; Clancey, 1985; Wick and Slagle, 1989]. These classifications can be condensed as subscribing to one of two possible criteria for distinguishing between the types of explanations. The first criteria is the nature of the explanation queries. For example, Wick and Slagle [1989] discuss explanations whose queries begin with What, Why, How, When, Where, etc. As well, Neches, Swartout, and Moore [1985] consider the How, Why, When, and What range of queries, as part of XPLAIN's explanation facility. The second criteria is the nature of the explanation responses. Swartout and Smoliar [1987] distinguish between explanations that provide terminological knowledge, domain descriptive knowledge, and problem-solving knowledge. Wexelblat [1989] suggests that KBS users require information about procedures, reasoning traces, action goals, control, and self-knowledge. Gilbert [1988] presents two ways of distinguishing explanation responses. First, responses can provide case-specific knowledge, domain knowledge or meta knowledge. Second, they can provide taxonomic knowledge, formal knowledge, contingent knowledge, or control knowledge.

Irrespective of whether they are based on explanation queries or explanation responses, there is a major problem with all these classifications. Lacking a sound theoretical basis, the various types of explanations that comprise each of these classifications are neither consistently defined, nor is each classification comprehensive. However, largely based on Clancey's [1983] characterization of the epistemological roles that knowledge can play in KBS explanation, a consensus has emerged on the three primary types of explanations that KBS ought to provide [Southwick, 1991, p. 3; Ye, 1990]. Corresponding to the three epistemological roles of structure, support, and strategy, these three types of explanations are: 1) trace explanations that describe contents and reasoning (structure), 2) deep explanations that justify underlying reasons for a state or an action based on
causal models (support), and 3) strategic explanations that clarify problem-solving strategy and meta-knowledge (strategy). This taxonomy of the three primary types of explanations, has also led to a convergence of opinion on the matching of explanation queries with explanation responses. This is as follows: the How explanation queries are used to provide trace explanations, the Why explanation queries are used to provide causal justifications, and the Strategic explanation queries are used to provide clarifications of control strategies and meta-knowledge. These three types of explanations will be adopted in this dissertation.

3.1.3 Feedforward and Feedback Explanation Provision and the Types of Explanations

The feedforward and feedback explanation provision strategies that were developed in

**Feedforward Why** explanations justify the importance of, and the need for, input information to be used or a procedure that is to be performed.

**Feedforward How** explanations detail the manner in which input information is to be obtained for use and procedures that are to be performed.

**Feedforward Strategic** explanations clarify the overall manner in which input information to be used is organized or structured, and specify the manner in which each input cue to be used fits into the overall plan of assessment that is to be performed.

**Feedback Why** explanations justify the importance, and clarify the implications, of a particular conclusion that is reached by the system.

**Feedback How** explanations present a trace of the evaluations performed and intermediate inferences made in getting to a particular conclusion.

**Feedback Strategic** explanations clarify the overall goal structure used by a system to reach a particular conclusion, and specify the manner in which each particular assessment leading to the conclusion fits into the overall plan of assessments that were performed.

| Table 3.1: Definitions of Explanations |

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Chapter 2 are relevant to all three of the Why, How and Strategic explanations, i.e., each of these types of explanations can be presented both as feedforward and feedback. Table 3.1 presents definitions for the three types of explanations when they are presented as feedforward or feedback. The feedforward explanations differ from feedback explanations as follows: (a) the feedforward version is not case-specific while the feedback version explains a particular case-specific outcome, (b) the feedforward version is presented prior to an assessment or diagnosis being performed while the feedback version is presented subsequent to the assessment and after the presentation of the outcome of that assessment, and (c) the feedforward version focuses on the input cues while the feedback version focuses on the outcomes.

The concepts of feedforward and feedback explanation provision can also be used to classify the manner in which the three types of explanations are provided in current KBS. As an example, Table 3.2 presents the manner in which MYCIN and its descendants presented their explanations.

<table>
<thead>
<tr>
<th>Type of Explanation</th>
<th>Explanation Provision Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why</td>
<td>Feedforward</td>
</tr>
<tr>
<td>How</td>
<td>Feedback</td>
</tr>
<tr>
<td>Strategic</td>
<td>Feedforward/Feedback</td>
</tr>
</tbody>
</table>

The Why explanations were presented in feedforward form, but the How explanations were provided in feedback form. The Why explanations provided by MYCIN presented information
clarifying the reasons a particular question was posed to the user. As these questions took the form of requests for input information and were posed prior to MYCIN performing a particular diagnosis, the explanations focused on providing declarative task information about the entities and relationships in a task domain. This is consistent with the definition of feedforward explanations. MYCIN’s How explanations provided information as to the basis for particular conclusions that were presented to the user. They focused on providing post-hoc explanatory information about the specific inference procedures used to arrive at each particular conclusion. This conforms to feedback explanation provision. While MYCIN did not provide Strategic explanations, they were incorporated by some of its descendants, i.e., NEO-MYCIN and GUIDON. In these systems, the Strategic explanations were provided both in feedforward and feedback form.

The exact reasons as to why these particular provision strategies are used for the various types of explanations remain unaddressed. However, it suggests that there could be a close relationship between the types of explanations and the feedforward and feedback explanation provision strategies.

3.1.4 Literature Review of Past Studies of the Use of KBS Explanations

Three empirical studies of the use of explanations as part of the user-KBS interface were found in the literature.

Lerch et al., [1990] focused on some effects of the use of KBS explanations. They measured user agreement with, and confidence in, conclusions presented by a KBS. Subjects were told that these conclusions were obtained from one of three different “sources of advice” --- novices, experts
or a knowledge-based system. As well, they used three different treatment conditions --- no explanations provided, explanations provided in the form of English sentences, and explanations provided in production rule form. They found that while the use of explanations had an impact on the level of user agreement with the conclusions, it did not change users' confidence in the source of advice on which the conclusions was modelled. The different types of explanations were not considered in this study, rather a generic category closely resembling the How explanation was used.

In another study, Ye [1990] had subjects evaluate explanations presented in a fixed sequential order and compared user perceptions of usefulness and user preferences for the three different types of explanations. The types considered were labelled as the Trace, Justification, and Control explanations. The first two are analogous to the How and Why explanations of MYCIN [Shortliffe, 1976], and the third to the Strategic explanations found in NEOMYCIN [Hasling et al., 1984]. Ye found that the use of explanations had a positive effect on user agreement with KBS conclusions and that the Why explanation was the most preferred explanation across levels of user expertise and types of inference used for heuristic classification tasks. As well, experts and novices were found to have differing perceptions of usefulness for the various types of explanations presented. Experts perceived the How explanation as being most useful, and novices the Why explanation. The primary weakness of this study was that the context used to collect the measures of user preference and perception of usefulness was not representative of the usual context in which explanations are used. The primary goal of the experimental task that was performed by subjects, was to evaluate and criticize the explanations that were presented, instead of the use of explanations in a problem solving or decision making situation involving the use of a KBS. As well, the study
also assumed that experts and novice subjects would have a generic preference for one of the types of explanations, irrespective of the problem-solving context involved.

In a field study, Lamberti and Wallace [1990] investigated interface requirements for knowledge presentation in knowledge-based systems. They examined interactions between user expertise, knowledge presentation format (procedural versus declarative formats), question type (requiring abstract versus concrete answers), and task uncertainty, in terms of the speed and accuracy of decision making performance. They found that for highly uncertain tasks, response time and accuracy for questions with declaratively formatted explanations (as compared to procedural ones) was better for higher skill users. However, for low uncertainty tasks the low-skilled subjects performed equally fast, but more accurately than high-skill users, when presented with declarative explanations to questions. Also, for explaining the procedures used in strategies of problem solving, both high and low skill users felt more confident with procedural explanations in contrast to declarative explanations. In relation to concrete versus abstract knowledge organization, the study found that low skill users performed significantly faster and more accurately when answering questions requiring concrete knowledge organization. High-skill users performed faster, although not necessarily more accurately, when responding to questions requiring abstract knowledge organization, in contrast to concrete knowledge organization.

The Ye study focused on capturing user perceptions for three different types of explanations that were presented sequentially to users. The Lerch et al. study focused on comparing the effects of explanations with varying levels of source credibility. The Lamberti and Wallace study, while only indirectly investigating explanations, investigated issues relating to the content of explanations.
The objective of this research is to add to this knowledge by focusing on other aspects of the provision and use of KBS explanations which have not been addressed as yet. These include investigating the influence of providing feedforward versus feedback types of explanations on the use of explanations, and the manner in which the use of KBS explanations affects both the accuracy of judgmental decision making as well as user perceptions of usefulness. Prior to a discussion of these, the various factors that influence the use of explanations are discussed in the next section.

3.2 A Framework of the Factors that Influence the Use of KBS Explanations

Figure 3.1 presents a host of factors that potentially determine both the amount and the types of KBS explanations that are used. These factors can be classified into four separate categories relating to the characteristics of: 1) the task setting, 2) the explanations provided, 3) the interface design and explanation provision strategies used, and 4) the users.

3.2.1 Task Characteristics

The nature of the KBS task and the context in which the KBS is used comprise the first category of factors that will influence the amount and the types of explanations used. The types of tasks that KBS perform can be categorized by various classifications, including analysis tasks versus synthesis tasks [Gaines and Boose, 1985], and heuristic classification tasks versus heuristic configuration tasks [Clancey, 1985], etc. While these classifications overlap to some extent, each of them can be further decomposed into a larger hierarchy of many levels of tasks. For example, the heuristic classification task can be decomposed into the three inference processes (sub-tasks) of data abstraction, heuristic match and solution refinement. Similarly, Waterman [1986] offers a breakdown of analysis tasks into sub-categories such as diagnosis, prediction, etc. The Ye [1990]
TASK CHARACTERISTICS

1. Task Type: - analysis
   - synthesis

2. Context of Use
   - end user applications
   - knowledge base debugging
   - knowledge base validation

EXPLANATION CHARACTERISTICS

1. Explanation Type - Why
   - How
   - Strategic

2. Explanation Content
   - amount of information
   - abstract versus concrete
   - granularity and specificity
   - focus to user groups
   - emphasis

INTERFACE DESIGN & PROVISION STRATEGY

1. Provision Strategy - feedforward, feedback

2. Accessibility - active strategy
   - passive strategy

3. Communication Mode - audio/visual

4. Presentation Format - text/image/animation

USER CHARACTERISTICS

1. User Expertise - domain expertise
   - system expertise

2. Individual Differences: Cognitive & Personality

3. Level of User Agreement

Figure 3.1: Determinants of the Use KBS Explanations
study directly investigated the influence of varying task types on the preference for the three types of explanations, by utilizing the data abstraction and heuristic match levels of heuristic classification as independent variables. However, it did not find significant differences in the preference for explanations between the two levels. The use of explanations that are provided by KBS performing synthesis or heuristic configuration tasks, such as design or planning, has not been studied. Considering the critical differences between these tasks and the more common diagnostic tasks, it is reasonable to expect that they will result in different patterns of KBS explanation use.

The context in which a KBS is utilized will determine the purpose for which the explanation facility is used. This will directly influence the use of KBS explanations. Three contexts for the use of KBS explanations can be identified: 1) by end-users in problem-solving contexts, 2) by knowledge engineers in carrying out knowledge-base debugging activities [Southwick, 1991], and 3) as part of KBS validation activities carried out by domain experts and/or knowledge engineers. The distinctions between these three contexts are critical and stem from the fact that the use of KBS explanations in systems development is motivated by a different set of objectives than when used as part of end user applications. It can therefore reasonably be expected that end users of KBS applications will use explanations differently from when they are used during debugging, validation, or other KBS development activities.

While explanations are commonly incorporated into most end user applications of KBS, they also play a significant role in the development of KBS by offering enhanced debugging and validation abilities. Most current KBS development shells and environments include tools that utilize explanations to aid efficient and effective system development, e.g., the Knowledge Engineering
Environment (KEE) from Intellicorp. Another example is the REPORT command in the VPExpert [Paperback Software, 1988] shell. This command lists in sequential order all the explanations attached (using the BECAUSE clause) to rules that 'fired' as part of a consultation. Such a listing assists in the debugging of processing logic by knowledge engineers. It also allows users and domain experts, who may not be familiar with representation schemes and inference engines, to participate in the validation of a knowledge-base.

In contrast to debugging and validation, the use of explanations by end users of KBS applications is motivated by a different set of reasons. For example, Lamberti and Wallace [1990, p. 302] suggest that an explanation facility is used: 1) by decision makers because it aids them in formulating problems and models for analysis, 2) by sophisticated users because it assures them that the system’s knowledge and reasoning process is appropriate, and 3) by novice users because it can instruct them about the knowledge in the system as it is applied to solve a particular problem. There are also a variety of contexts in which end user applications of KBS are used. For example, while some applications are used as tools for training novices in a domain, others are used by experts to support their own decision making. The organizational context in which these end user applications are used will also affect the use of the explanations. Sviokla [1986] notes that some organizations institutionalize the use of such KBS applications for making certain critical decisions. The use of explanations when end-users are compelled to use the KBS will certainly be different from the situation when end-users utilize the KBS as a decision aid by choice. In summary, many different context of the use of KBS can be identified as potentially influencing the use of KBS explanations. However, the influence of this critical factor has not been investigated to-date.
3.2.2 Characteristics of the Explanations that are Provided

The nature of the explanatory information that is provided by a KBS to its users will certainly influence the explanations that are used. These can be divided into two major categories: explanation type and explanation content. While the types of explanations were discussed in Section 3.1.2, there is considerable overlap between these two categories. The three types of explanations are by definition different in content. For example, the Why explanations focus on providing declarative information about the task, the How explanations provide procedural task information, and the Strategic explanations present meta-knowledge of the task. Similarly, the various types of explanations will also differ in content in relation to whether they are provided as feedforward or feedback. For example, feedback explanations, being outcome specific, will by definition be more concrete and at a lower level of specificity than the more generalized feedforward explanations.

While the investigation of the influence of the types of explanations is potentially more relevant, largely because both KBS developers and users distinguish clearly between them, it is also possible to study directly the influence of various dimensions of content, e.g., the Lamberti and Wallace [1990] discussed in Section 3.1.4. Some relevant dimensions of explanation content include the following. The informational content of the explanations in terms of the number of signals that are incorporated represents the first dimension. The second dimension is the abstraction level of the explanations, i.e., how concrete or abstract they are from the perspective of users. The third dimension is the granularity and specificity of the explanations, e.g., the lowest level will have the most amount of detail and vice versa. Fourth, explanations can be focused towards particular user groups, such as knowledge engineers, domain experts and end users, or they can have a more general focus. Terminological differences in explanations can be expected depending on who are
the target users of the explanations. Fifth, explanations can emphasize different aspects of that which is being explained, e.g., procedural aspects in contrast to declarative aspects.

### 3.2.3 Interface Design and Provision Strategies

The design features of the interface used to provide explanations, as well as the strategies used for providing explanations, will also influence the patterns of KBS explanation use. Specific aspects of the interface design include the following. First, the amount of effort required for users to access the explanations, i.e., the accessibility of the explanations, will influence their use. Two possible classes of strategies for accessing explanations can be identified. These include an *active* strategy where the KBS presents explanations without the user having to request them, and a range of *passive* strategies that require the user to make varying levels of explicit physical effort to access the explanations. Such effort can range from clicking on specialized explanation icons presented on the screen to hitting predesignated function keys for accessing and scanning the explanations. Generally, an active strategy has the system interrupt the dialogue to provide explanations or makes them available continuously as part of every screen of the KBS. In the design of KBS explanation facilities, it is important that interface designers consider the amount of effort that is required for users to request and access the explanations. The results of recent studies of cost-benefit models of the effort involved in utilizing computerized decision aids [Todd and Benbasat, 1991] suggest that the accessibility of explanations, i.e., the cost of accessing them, will exert a salient influence on the use of explanations. Second, the communication mode used for presenting the explanations, e.g., audio and/or visual modes, will also influence the use of explanations. Third, the presentation format utilized for the explanations is also a factor, e.g., text explanations in contrast to image-based explanations that use graphical, iconic and animation formats. The influence of all these
aspects of the interface used to provide KBS explanations, on the use of KBS explanations has not been investigated to-date.

Considering that the primary reason for the provision of KBS explanations is to improve users' understanding of the KBS and its domain, the feedforward and feedback explanation provision strategies conceptualized in Chapter 2 will also influence the use of explanations. The importance of these explanation provision strategies, that are based on the cognitive feedback paradigm, becomes obvious if one considers the analogy of a child engaged in a learning process to improve his or her understanding. While "an explanation machine", in the form of a child’s parents, may be continuously available to provide explanations about some phenomenon that is the target of the learning, the child will only seek, attend to, and benefit from explanations provided at particular stages of the learning process. At different stages of the process different types of explanations will be sought, and it can be expected children at varying stages of cognitive development will seek different amounts and types of explanations. As well, it is also likely that explanations provided automatically without being requested, will at times impede rather than encourage, the learning that takes place. This analogy therefore suggests that any evaluation of the influence of the explanation provision strategies must therefore take into consideration the other factors that are identified in the framework of Figure 3.1.

3.2.4 User Characteristics

Three distinct categories of user characteristics that will impact the use of explanations can be identified --- user expertise, individual differences, and the level of user agreement with the KBS. Of these, user expertise is potentially the most significant to the design and use of KBS
explanations. Section 2.4.2 of Chapter 2, which considered the role of feedforward and feedback explanations within the three stages of Anderson's [1982] theory of skill acquisition, suggests that user expertise will influence the use of explanations. As well, all the three empirical studies of KBS explanations that were discussed in Section 3.1.4, have found significant effects for this factor. All these studies used users' knowledge of the task domain to operationalize user expertise. However, the human-computer interface literature reveals another aspect of user expertise that can be considered as being just as relevant. This is the level of users' expertise or familiarity with knowledge-based systems themselves [Lehner and Zirk, 1987]. This is termed in Figure 3.1 as systems expertise. The influence of this dimension of user expertise on the use of KBS explanations has not yet been studied.

Various types of cognitive and personality based individual differences can also be identified, primarily from the literature on decision support systems (DSS), as potentially influencing the use of KBS explanations. However, while much is known of their influence on human cognitive functioning, they suffer from a lack of an adequate and coherent theoretical basis [Huber, 1983]. Additionally, as is now recognized in the study of DSS, there is only a small likelihood that an individual differences approach to the design of decision aids will yield practical and cost-beneficial design requirements. These individual differences have not been studied in the context of the use of KBS explanations.

The final category of user characteristics that can be identified is the level of user agreement with the KBS. Both the Ye [1990] and the Lerch et al. [1990] studies found that the use of explanations increased the level of user agreement with KBS conclusions. This finding, together
with the finding that experts were more likely to agree with a KBS's conclusions than novices [Ye, 1990], suggests that there could potentially be a reverse effect as well. The level of initial user agreement with KBS conclusions would influence, to some extent, the amount of explanations that are used. As the differences in the level of domain expertise can result in different levels of agreement with a KBS's conclusions, this suggests that the level of user agreement potentially moderates the influence of user expertise on the use of explanations.

In summary, this section has identified a variety of factors that could potentially influence the use of KBS explanations. Any study of a subset of these factors, e.g., the feedforward and feedback provision of explanations, has to consider and account for the potential influence of the other factors as well. The next section presents the second part of the investigative framework for the use of KBS explanations. It focuses on the effects of the use of KBS explanations.

3.3 A Framework for Investigating the Effects of the Use of KBS Explanations

KBS explanation facilities will only be utilized by KBS users if they obtain some real or perceived benefit from their use. Conversely, it may be argued that some KBS users will utilize explanations because they are not able to perceive the detrimental effects of such use. Currently, we know very little about the effects of the use of KBS explanations, especially in applied settings where the KBS is used as a decision aid. Lerch et al. [1990] conducted the only study that has directly investigated some effects of the use of explanations. They found that the use of explanations has an effect on the level of user agreement with KBS conclusions but has no effect on users' confidence in the KBS. This study proposes to test the effects of the use of KBS explanations that are provided as feedforward and/or feedback in an applied setting where a KBS is used as a decision aid.
aid to make judgments under conditions of uncertainty. Prior to a discussion of this, however, it is important to consider all the possible effects that the use of explanations may have in such a setting. Viewing KBS explanations as a decision aid, this section therefore discusses potential dependent variables that can be used for investigating the effects of the use of KBS explanations.

Figure 3.2 depicts four categories of dependent variables that can potentially be used for the investigation of the effects of the use of KBS explanations. The first category relates to user behavior in interacting with the KBS. Various measures of the change in users behavior arising from the provision of explanations comprise this category. As was discussed in Chapter 2, the use of explanations may lead to an increase in user understanding of the KBS and the task domain. This represents the category of learning effects. Learning effects moderate the relationship between the use of explanations and the categories pertaining to perceptions and judgmental decision-making (JDM). The perceptions category encompasses the changes in the perceptions and intentions of users caused by the learning fostered by the use of the explanations. They can also be termed as "perceived" effects. The category pertaining to judgmental decision-making (JDM) relates to the manner in which the increased user understanding of the task domain and the KBS influence the quality of the users' decision making. Considering that knowledge-based systems that are used as decision aids have the facilitation of decision making as their primary objective, this category can be regarded as being the most important category of effects.
3.3.1 Effects on Judgmental Decision Making

The success or failure of any information technology has to be evaluated in terms of the objectives of the use to which it is put. An assumption underlying the design of decision support systems is that the incorporation of a particular design feature, e.g., KBS explanations, will increase the effectiveness of decision performance and/or the efficiency of the decision process. Based on this, Keen and Scott Morton [1978] argue that the appropriate dependent measures for evaluating decision aids can be categorized as being either measures of effectiveness or efficiency. Typically, effectiveness indicates the quality or accuracy of the decisions made, and efficiency denotes the decision speed. For example, while laboratory studies of DSS have used measures such as the levels of profit, cost, and the number of alternatives considered, as effectiveness criteria, decision
efficiency has usually been measured by decision time [Sharda, Barr, and McDonnell, 1988]. There have been no studies to-date that have investigated the effect of the use of KBS explanations on either decision effectiveness or efficiency.

Ideally, *objective and observable* measures of decision effectiveness and/or efficiency represent the best dependent variables for evaluating the effects of the use of any decision aid, including KBS explanations. However, for the lack of valid measures that meet these critical criterion, DSS researchers often have to fall back on using other "surrogate" measures. These usually belong to either the category of perceived effects or the category of behavioral effects in Figure 3.2. In such situations, it is essential for these measures to map faithfully the underlying theoretical constructs in a valid and reliable manner.

3.3.2 Behavioral Effects

In the absence of good direct measures for decision effectiveness and/or efficiency, behavioral measures of the use of a decision aid have been used as substitutes. The underlying assumption has been that users will only use a decision aid if they perceive some value in terms of decision effectiveness or efficiency. While recent studies, that indicate user perceptions of the value of decision aids can suffer from an "illusion of control" [Kotteman, Davis and Remus, 1993], suggest that this may be an invalid assumption, the "system use" construct has the advantage of being an observable and objective construct. Measures can generally be collected unobtrusively by having the computer keep counts of the frequency and the lengths of time that various features of the decision aid are accessed. While most DSS studies have utilized this approach to measurement, others have also relied on having participants report the frequency of their use.
In the context of KBS, the "system use" construct has also been considered to be synonymous with *user acceptance* [Shortliffe, 1984; Chandrasekaran, Tanner and Josephson, 1988], i.e., if users make use of a particular feature of a KBS they can be considered to have accepted it. In the context of KBS explanations, this argument has also been used as a justification for providing KBS explanations. This has led some researchers to note that "an intriguing, but little researched, aspect of the expert systems literature is the argument that it is essential to provide a capability to explain results obtained by a program in order to increase user acceptance" [Lerch, Prietula and Kulik, 1990, p. 8]. KBS explanations can effect users "system use" behavior in many ways. For example, measures of the total time that elapses when KBS explanations are accessed during a consultation can be used to assess the use being made of the explanations. As well, computer logs of users' interaction with the KBS can be used to assess if 1) there are differences in the manner in which the various types of explanations are utilized, 2) there are changes in user behavior as a result of being provided with feedforward and/or feedback explanations.

### 3.3.3 Perceived Effects of the Use of KBS Explanations

While perceived effects can also be used as measurement proxies for the effects on decision effectiveness or efficiency, they also represent an important set of effects in their own right. This is because users' future behavior, in relation to the use of a decision aid, is often motivated just as much as by their perceptions of the benefits that accrued from past use, as by the "real" benefits that were obtained. The information systems literature suggests that user intentions, and at least four categories of user perceptions or attitudes will be affected by the use of explanations. These are shown in Figure 3.2. The critical role of intentions arises from the work of Davis, Bagozzi and Warshaw [1989]. They tested models based on Fishbein and Ajzen's [1975] Theory of Reasoned
Action to demonstrate that system use can be predicted reasonably from people's intention to use. Additionally, they also demonstrated that perceptions of usefulness and ease-of-use are significant determinants of the intentions to use a system. Recent work by Moore and Benbasat [1991] provides a further refinement of these categories of perceptions. They demonstrate that perceptions of voluntariness, trialability, compatibility, visibility, and result demonstrability underlie the intention to use a particular system and are significant determinants of the adoption of a system. While all these perceptions could be used as dependent variables in the study of the effects of the use of explanations, Figure 3.2 isolates the four that can be deemed to be the most relevant. These are the perceptions of trust, user satisfaction, ease of use, and usefulness.

The primary category of perceptions that will be affected by the use of KBS explanations is the perception of user trust in a system and its output. For example, Swartout [1983] argues that "trust in a system is developed not only by the quality of its results, but also by a clear description of how they are derived," and Muir [1988] suggests that "a decision aid, no matter how sophisticated or intelligent it may be, will be rejected by a decision maker who does not trust it". Various theoretical components of trust, such as dependability, predictability, and faith, are discussed in the literature [Rempel, Holmes, and Zanna, 1985]. However, unlike the case of user perceptions of usefulness, ease-of-use, and satisfaction, no concise and reliable measurement instrument for trust has been developed yet. Empirical investigations of trust have therefore largely utilized measures of 1) user confidence, and 2) user agreement with system recommendations, as operationalizations of the construct, e.g., see Lerch, Prietula and Kulik [1990].

While the nature of the theoretical association between confidence and trust is unclear, user
confidence can be measured using two approaches. First, perceptions could be captured using questionnaire-type, multi-item instruments that measure its various theoretical sub-constructs. While, many studies of DSS have measured user confidence as a secondary dependent variable using this approach, most have relied on using a single item Likert-type scale and have not considered the theoretical basis for the measurement [Aldag and Power, 1986; Cats-Baril and Huber, 1987; and Sharda, et al., 1988]. No attempt has been made to develop a multi-item instrument for measuring confidence reliably and in a valid manner. The second approach to measuring confidence involves having users provide probability estimates of their confidence in judgments that they make. This approach has been used and investigated extensively in the context of the accuracy of judgment and choice in decision making [Lichtenstein, Fischhoff, and Phillips, 1982; Abelson and Levi, 1985; Sniezek, Paese and Switzer, 1990]. Using this approach, user confidence is decomposed into its two sub-constructs of calibration and resolution, which are considered to be independent skills that are closely related to the exercise of accurate judgmental performance [Yates, 1982]. Calibration is the decision-maker's ability to assign appropriate probability levels to judgments, while resolution refers to the decision maker's ability to discriminate correct from incorrect judgments by differentially assigning confidence judgments to accurate and inaccurate judgments. The effects of the use of KBS explanations on the calibration and resolution sub-constructs of user confidence have not been studied yet. However, by using the first approach, i.e., a single item Likert-type scale, Lerch et al. [1990] found that the use of explanations had no effect on user confidence in a KBS.

The effect of the use of KBS explanation on user agreement with KBS conclusions has been investigated by both Lerch et al. [1990] and Ye [1990]. While only the Lerch et al. study directly considered the linkage of user agreement to user perceptions of trust, both studies found that the
use of explanations improved user agreement with the KBS. In the two studies, user agreement was measured using a single-item, Likert-type scale.

User perceptions of satisfaction represent the second category of perceptions that will be affected by the use of KBS explanations. The use of various scales for capturing perceptions of user satisfaction, as a surrogate measure for the effectiveness of a decision aid, is well established in the DSS literature [Bailey and Pearson, 1983; Ives, Olson and Baroudi, 1983; Jenkins and Ricketts, 1985; Baroudi and Orlikowski, 1988]. While the theoretical underpinning of user satisfaction as a valid theoretical construct is weak, Melone [1990] has argued that there is a fundamental similarity between it and social and cognitive psychologists’ notion of an attitude. While it could reasonably be hypothesized that the clarifications provided by KBS explanations will have a positive effect on user perceptions of satisfaction with the KBS, this effect has not been investigated yet.

In Figure 3.2, the perceptions of ease-of-use and usefulness constitute the third and fourth categories of the perceptual effects arising from the use of KBS explanations. Valid and reliable instruments exist in the information systems literature for measuring these constructs [Davis, 1986; and Moore and Benbasat, 1991]. The inclusion of explanations as part of the user-KBS interface increases its complexity. This could mean that explanations may have a negative effect on user perceptions of the ease of use of a KBS. This effect has not been investigated yet. Perceptions of usefulness focus on the degree to which users perceive that using a particular decision aid enhanced their task performance. Generally, the use of KBS explanations can be expected to lead to more positive user perceptions of usefulness. Ye [1990] investigated the effect of using the three types of explanations on user perceptions of usefulness. He found that the use of the Why and How
explanations resulted in more positive perceptions of usefulness than the use of Strategic explanations.

3.3.4 Learning Effects of the Use of KBS Explanations

In Figure 3.2, the learning construct of user understanding moderates the influence of the use of explanations on the perceived effects. For example, it is a precondition that before a system can be perceived as being trustworthy, easy-to-use, or useful it must first be comprehensible and clear to its users. As well, users will only be satisfied and confident with systems that they understand and comprehend. This argument is consistent with the assertion of current theories of mental models [Norman, 1983], cognitive learning [Balzer et al., 1989], and framing effects [Minsky, 1975] that people's perceptions of the world are shaped by the understanding that they already possess. As a consequence of its role in moulding user perceptions, the user understanding that is fostered by KBS explanations can be expected to be a significant determinant of the intention to use a KBS and its explanations in the future. User understanding also moderates the influence of the use of explanations on the efficiency and effectiveness of judgmental decision making. It can be argued that users will demonstrate more effective and efficient decisional performance, when using KBS explanations, largely because the improved user understanding of the task that is fostered by the explanations will allow them to perform better. This is consistent with, and supported by, the findings of the research based on the cognitive feedback paradigm, which was discussed in Chapter 2. Measurement of the learning, i.e., the improved understanding that is fostered, can therefore be considered to be a critical dependent measure representing the effects of the use of KBS explanations.
There are two ways in which user understanding can potentially be operationalized in KBS studies. First, it can be measured using multi-item scales to capture user perceptions of learning. Second, it can be operationalized as defined by the conversation theory of learning [Pask, 1976]. This theory views teaching as being the passing of one's understanding to others and learning as the gaining of an understanding. Teaching and learning develop as the participants, e.g., the explanation facility and the user, reach agreements about the subject matter. It also defines understanding as being the ability to reconstruct or develop the concept learned either when it is forgotten or when circumstances have changed. A critical implication of the theory is that the agreements that are reached by the participants can be demonstrated by testing. Thus, the approach to the measurement of user understanding should not be the collection of perceptual measures but rather testing if subjects are 1) able to reconstruct the concepts when forgotten, or 2) able to adjust the concepts to changing situations.

3.4 Hypotheses

Chapter 2 provided a cognitive learning theoretical basis for KBS explanations by conceptualizing their provision as feedforward and feedback. These feedforward and feedback strategies for providing KBS explanations were evaluated within the comprehensive framework for investigating KBS explanations. In doing so, three fundamental research questions were addressed: 1) To what extent are explanations used in judgmental decision-making situations involving the use of a KBS? 2) What factors influence the use of KBS explanations? and 3) Does the use of explanations empower KBS users in any way? This section formulates and states several hypotheses that explore these research questions.
Figure 3.3 presents the research model that will be used. To investigate the first and second research questions, this research will study three of the factors that were identified in Section 3.2 (see Figure 3.1) as potential determinants of the use of KBS explanations. It will investigate how explanation provision strategies, together with user expertise and the types of explanations provided, influence the use of KBS explanations. User expertise was identified in Section 2.4.2 of Chapter 2 as being a relevant variable that could potentially affect the effectiveness of the feedforward and feedback explanation provision strategies. As well, Section 3.1.3 of this chapter, which discussed the relationship between the types of explanations and the explanation provision strategies, provided the basis for the inclusion of the types of explanations as a relevant variable. Table 3.3 presents the
Main Effects
H1: Feedback explanations will be used as much as the feedforward explanations.

H2: Novices will use more explanations than experts.

H3: The why explanation will be used the most, and the how explanation will be used more than the strategic explanation.

Interaction Effects
H4: Novices will use more feedforward explanations than feedback explanations, while experts will use more feedback explanations than feedforward explanations.

H5: For both feedforward or feedback explanation provision, the why explanation will be used the most, and the how explanation will be used more than the strategic explanation.

H6a: Novices will use the why explanation the most, and the how explanation more than the strategic explanation.

H6b: Experts will use the how explanation the most, and the strategic explanation more than the why explanation.

H7a: For both feedforward or feedback explanation provision, novices will use the why explanation the most, and the how explanation more than the strategic explanation.

H7b: For both feedforward or feedback explanation provision, experts will use the how explanation the most, and the strategic explanation more than the why explanation.

Table 3.3: Hypotheses Relating to the Determinants of the Use of Explanations

specific hypotheses that will be used. Hypotheses 1 through 3 directly test the influence of the three factors independently, while Hypotheses 4 through 7 focus on the influence of their interactions.

Considering that evidence from prior research indicates that 1) the level of user agreement has a significant relationship with the use of explanations, and 2) there are expert-novice differences in user agreement, the study will also investigate the influence of the initial level of user agreement with KBS conclusions on the use of KBS conclusions. The specific hypotheses relating to this are
H8: There is an inverse relationship between the level of user agreement and the number of feedback explanations used.

H9: The relationship between the level of user agreement and the number of feedback explanations used will be the same for experts and novices.

H10: There is no difference in the level of user agreement between experts and novices.

**Table 3.4: Hypotheses Relating to the Influence of User Agreement**

presented in Table 3.4. Hypothesis 8 postulates that there will be an inverse relationship between the level of initial user agreement and the amount of explanations that are used. Hypothesis 9 tests the mediating influence of the level of user agreement on the relationship between user expertise and the use of KBS explanations. As well, Hypothesis 10 tests for expert-novice differences in the initial level of user agreement with KBS conclusions.

The third research question is investigated using two of the various effects of the use of KBS explanations that were identified in Section 3.3 (see Figure 3.2). As shown in Figure 3.3, the first of these is the effect on the accuracy of judgments, which represents the effectiveness of judgmental decision making. Table 3.5 states the specific hypotheses that are used to assess this effect.

H11a: The use of feedforward explanations will improve the accuracy of judgments.

H11b: The use of feedback explanations will improve the accuracy of judgments.

H12a: The use of Why explanations will improve the accuracy of judgments.

H12b: The use of How explanations will improve the accuracy of judgments.

H12c: The use of Strategic explanations will improve the accuracy of judgments.

**Table 3.5: Hypotheses Relating to the Influence of the Use of KBS Explanations on the Accuracy of Judgments**
Hypothesis 11a tests for the influence of the use of feedforward explanations, while Hypothesis 11b tests the influence of the use of feedback explanations. Hypotheses 12 a, b, and c focus on the influence of the use of the three types of explanations. The second effect explored is the effect on user perceptions of usefulness. This represents a perceived effect in Figure 3.3. The specific hypotheses relating to it are stated in Table 3.6. Hypotheses 13 a and b test the influence of the use

H13a: The use of feedforward explanations will improve user perceptions of usefulness.
H13b: The use of feedback explanations will improve user perceptions of usefulness.
H14a: The use of Why explanations will improve user perceptions of usefulness.
H14b: The use of How explanations will improve user perceptions of usefulness.
H14c: The use of Strategic explanations will improve user perceptions of usefulness.

Table 3.6: Hypotheses Relating to the Influence of the Use of KBS Explanations on User Perceptions of Usefulness

of feedforward and feedback explanations, while Hypotheses 14 a, b, and c test the influence of the use of the three types of explanations. The selection of the accuracy of judgment effect for investigation is based on the discussion, in Section 2.2.3.3 of Chapter 2, of past research that compared the relative efficacies of the feedforward and feedback cognitive learning operators in fostering the learning of judgmental decision making. User perceptions of usefulness were also selected as a dependent variable because Ye [1990] had found significant differences in these perceptions for the different types of explanations that were provided to KBS users. As well, it was felt that the selection of a "perceived" effect, together with a "real" one, would add to our understanding of how the use of KBS explanations empowered KBS users.
3.5 **Summary of the Chapter**

In this chapter, the use of explanations was first defined and significant prior research in the area was reviewed. The second and third sections then presented a two-part framework for studying the determinants and effects of the use of KBS explanations. This framework formed the basis for the research model that was then presented in Section 3.4. This research model comprises the pertinent variables identified, in both Chapter 2 and the first part of this chapter, as being relevant to the assessment of the provision of KBS explanations as feedforward and feedback. Section 3.4 also used the research model to state hypotheses about relationships among the variables. The chapters that follow describe an experiment that was carried out to test these hypotheses.
CHAPTER 4: THE TASK DOMAIN AND THE DEVELOPMENT AND VALIDATION OF THE EXPERIMENTAL SYSTEM

4.0 Introduction

This chapter describes the task domain that served as the context for the investigation of the determinants of the use of KBS explanations and their impact. It also discusses the development of the various stimulus material used in the investigation including the Canacom financial analysis case, the MOUSE and CREDIT-ADVISOR tutorial systems, and the FINALYZER-XS experimental knowledge-based system (KBS). As well, the results of various tests carried out to ascertain the experimental realism [Swieringa and Weick, 1982] of the experimental task material and the validity of the explanations provided by the experimental system are reported.

4.1 Selection of the Domain and the Task Application

Selection of the specific context that was used in this study was done in two steps. Initially, an appropriate administrative domain was identified. Next, the various types of task applications within this domain were evaluated to yield a suitable one. These two steps are discussed separately below.

4.1.1 The Domain

Several factors can be used to distinguish between application domains in which knowledge-based systems have been developed. These include the levels of complexity, the degree of
uncertainty, the size of the problem space, and the levels of both perceived structure [Keen and Scott-Morton, 1978] and deep structure [Chomsky, 1971]. As KBS are used to solve complex, unstructured problems, it was important for the domain selected to have sufficient levels of complexity, uncertainty, and problem size so that users could perceive the need for a KBS of high quality. These levels can generally be controlled by the selection of application tasks within a domain. The two dimensions of the domain structure, on the other hand, cannot be controlled in this manner. The underlying deep structure of a domain that specifies the relationships in its problem space is usually fixed, irrespective of the particular task selected. Perceived structure, as reflected by the extent to which there exists a well-defined and specified body of knowledge in the domain, is also independent of the task selected.

Considering the above factors, the financial evaluation domain was selected to be the experimental domain. It offered an adequate level of deep structure to make the development and use of a KBS worthwhile from a user’s perspective. As well, the high specificity of its domain knowledge, which is based on the well-specified double-entry model of financial accounting, ensured that knowledge acquisition to develop such a system would be facilitated. The domain selected was validated against Zanakis and Evan’s [1989] characterization of domains where the use of knowledge-based heuristics is most applicable. Considering that financial evaluation is too complex for simple optimization models and algorithms [Duchessi, Shawky and Seagle, 1988, p. 57], requires both quantitative and qualitative inputs, and involves both symbolic and numeric reasoning [Bouwman, 1983] it rated positively on this evaluation. Other considerations that also supported the selection of this domain include the following: 1) its extensive use in the financial sector meant that sufficiently large numbers of domain experts and experimental subjects would potentially be
available to participate in the study; 2) the researcher's past training in financial accounting would be an asset in the design of the experimental system; and 3) the long history of the use of financial evaluation in the study of computer modelling of human diagnostic reasoning [Bouwman, 1978 and 1983] and the increasing interest in knowledge-based approaches to financial accounting applications [Elmer and Borowski, 1988; Duchessi et al, 1988; Srinivasan and Kim, 1988; and Shaw and Gentry, 1988] could serve to guide the selection and development of the experimental material.

4.1.2 Selection of the Task Application

Various tasks within the financial evaluation domain were considered, using both of Clancey's [1985] heuristic classification and heuristic configuration task-types and the taxonomy proposed by Hayes-Roth et al, [1983, p. 14]: interpretation, prediction, diagnosis, design, planning, monitoring, debugging, repair, instruction, and control. Based on a review of the existing applications of financial knowledge-based systems [see for example the summary presented by Roy, 1989] and after consultation with several experts in financial management, the choices were narrowed down to two tasks. One was the "heuristic configuration" type task of designing financial investment plans for wealthy individuals by balancing a variety of financial objectives. This task is similar to that of the PlanPower expert system of Financial Designs, Inc., [Sviokla, 1986, p. 116]. The other was the "heuristic classification" type task of diagnosing the financial statements of companies to support loan granting and investment selection decisions.

Of the two options, the latter was selected as the experimental task for a variety of reasons. First, the bulk of current KBS perform diagnostic tasks that involve the identification of the state of an underlying system on the basis of a set of observable symptoms [Waterman, 1986]. As well,
all the past studies of KBS interfaces have used diagnostic tasks. The selection of the financial analysis task over the financial planning task would therefore facilitate the comparison of the results of this study to those of the prior studies. The second consideration was that since expertise in financial planning involves the integration of specialized knowledge about financial investments, tax planning, insurance, estate planning, retirement planning and related legal considerations, knowledge acquisition would be complex. A number of experts from these different fields would have to be recruited and their views consolidated. Sviokla [1986], notes that this can be an arduous task because these experts generally subscribe to significantly different principles and models of financial planning. Financial analysis expertise, however, is more focused and consistent. A smaller number of experts would be needed and they would generally be easier to recruit as there are more of them around due to the pervasiveness of the use of financial statement analysis.

Financial statement analysis involves the review of a company’s financial data to evaluate various aspects of its financial standing and performance. Based on such an assessment of underlying financial health, a whole range of business decisions are made. For example, while it is used primarily in the two decision contexts of investment portfolio selection and loan evaluation, it is also used for estimating a firm’s market risk (beta) and for predicting bond ratings [Brealey and Myers, 1984]. The loan evaluation decision context was selected to be the focus of the study. It was also decided that a commercial lending task would be more appropriate over a consumer credit task as both the composition of the financial statements and the expertise required to evaluate them would be complex enough to warrant the use of a KBS.

Seven major categories of financial ratios are commonly used in financial analysis: liquidity
ratios, leverage ratios, profitability or efficiency ratios, market value ratios, funds flow adequacy and reinvestment ratios, and common-size ratios of the individual items comprising both the balance sheet and the income statement. Additionally, other subjective factors affecting these ratios are also usually considered. Examples of these include the possibilities of losing major litigation battles, having foreign subsidiaries nationalized, competitors introducing significantly superior products, etc. As there are no absolute standards for these financial ratios, relative standards are generally used. This involves comparing a firm’s ratios to the same ratios in earlier years, and with the ratios of other firms in the same industry which are often summarized into industry composites.

4.1.3 Decision Support Aids for Financial Statement Analysis

The conduct of financial statement analysis generally involves three steps. Initially, the various categories of ratios are computed. Next, each category of ratios is evaluated to yield judgments relating to each of the various sub-aspects of financial analysis, such as liquidity, capital structure, profitability, etc. Finally, these judgments form the basis for the making of specific decisions or predictions. Various computerised decision aids are currently available to support the first step involving the computation of the ratios. Considering that it is a structured process [Gorry and Scott-Morton, 1971] with quantitative inputs and precisely defined transformation procedures, this step was the first to benefit from computerization. These decision aids generally take the form of spreadsheet-based financial analysis packages such as FSAP [Stickney, 1990] and FISCAL [Halcyon Group, 1990] and are used widely in industry. They facilitate decision support functions such as what-if analysis, sensitivity analysis, and goal seeking analysis [Sprague and Carlson, 1982].

The second step, involving the evaluation of the ratios to produce judgments, represents a
more unstructured process. It is characterized by the use of specialized domain-specific knowledge. This generally takes the form of industry-specific knowledge about: 1) the relevance and value of each of the ratios computed, and 2) the relative standards by which the values of the ratios are to be judged. Decision aids that incorporate such knowledge, such as knowledge-based systems, are needed to support this step of the financial analysis process. For example, Miller, Pople and Meyers [1982] have argued that a financial analyst would greatly benefit from knowledge-based systems that contain knowledge of specialized industries, just like a medical general practitioner greatly benefits from knowledge-based systems that cover medical specialties. Considering the large number of industries that exist and the fact that the boundaries between them are often fuzzy, especially with the large number of firms that have pursued diversification, it is no surprise that there does not exist a single commercialized multi-industry KBS available that supports this step of the financial analysis process. This situation is likely exacerbated by the significant cost and difficulties associated with the acquiring of such domain knowledge as part of the systems development process.

There is evidence, however, that various organizations have attempted the in-house development of financial analysis KBS that are focused on a limited set of industries. As reported by Roy [1989, pp. 331-332] and in the Expert Systems Strategies newsletter of Cutter Information Corporation [1988], these include the Authorizer's Assistant of American Express, the Letter of Credit Adviser of the Bank of America, the Financial Analyzer of the Athena Group, and the Implode system of the Security Pacific Merchant Banking Group. Established systems development organizations have also started offering services relating to the development of such systems, e.g., Arthur Andersen & Company's development of the Financial Statement Analyzer for the US Securities and Exchange Commission [McGee and Porter, 1988] and Arthur D. Little Incorporated's
development of the Indenture Analysis system. More recently, smaller specialized systems
development organizations have begun to appear in the market place to exploit this niche of
industry-specific KBS for financial statement analysis. In addition to providing specialized KBS
development assistance, they generally offer an integrated package of software capabilities, in the
form of a skeletal system or "shell", that is specifically constructed for the financial statement
analysis task. These shells can quickly and easily be customized or instantiated with the domain
knowledge of a particular industry to yield specific knowledge-based systems. Examples of these
include FAST ADVISOR of Financial Proformas Incorporated which is currently being used at the
Bank of Montreal [White, 1991], Power 1 of BancA Corporation which is used at the Canadian
Imperial Banking Corporation [Shaw and Gentry, 1988, p. 46], ANSWERS of Financial Audit
Systems Incorporated [Financial Audit Systems, 1992], and Lending Adviser of Syntelligence
Incorporated which is used at the Wells Fargo Bank [Syntelligence Marketing Material, 1990].

Step three of the financial analysis process involves the conversion of various financial
judgments into particular decisions or predictions. Decision aids for this step will therefore take the
form of "decision-taking" systems as compared to the "decision support" approach taken for the
previous step as discussed above. While this step is similar to step two in terms of being an
unstructured procedure requiring large amounts of domain knowledge for its resolution, the few
commercial decision support systems used in industry do not take the form of knowledge-based
system applications. Instead, algorithmic credit scoring approaches based on elaborate weighting
schemes, multivariate statistical methodologies, e.g., logit and discriminant analysis [Srinivasan and
Kim, 1988], and induction procedures [Shaw and Gentry, 1988] are used. As well, the use of these
decision aids is largely limited to applications relating to the analysis of personal financial statements
in consumer credit decisions. Of the three steps of financial analysis, this step is the least automated in industry. It has been suggested that the financial industry is reluctant to adopt the use of these aids in the more substantive corporate lending and investment situations primarily because of: 1) legal liability and accountability considerations arising from the use of such "decision taking" systems, and 2) the failure of these systems to take into consideration subjective factors relating to the maintenance of long-term business relationships between financial institutions and their clients [Kerkovius, 1992; White, 1991].

4.2 Development of the Experimental Material

Considering the current availability of decision support aids for financial analysis, as discussed in the last section, attempts were initially made to obtain the use of a commercial KBS used to support step 2 of the process. Although none of these KBS were known to incorporate any elaborate explanation provision facilities, it was felt that such a capability could be added for the purposes of this research. As well, attempts were made to obtain the participation of a local financial institution that was in the process of implementing such a KBS. When these efforts proved fruitless, a simulation approach was decided upon, whereby a simulation of the interface of a hypothetical KBS for financial analysis would be developed and subjects using it convinced that they were interacting with a functional KBS. This simulation approach has been commonly utilized in laboratory studies testing new human-computer interfaces [Good, et al., 1984]. In the context of KBS interface design, it has been used by Ye [1990] as was discussed earlier. However, before a simulation could be developed, it was first necessary to determine the exact details of the experimental task to be used. This was because the simulation to be developed had to meet all the requirements for completely solving this task. The development of this is discussed next.
4.2.1 Development of the Canacom Experimental Case

Specific criteria used in the development of the case included the following. First, the task had to be non-trivial so that subjects could perceive the need for a KBS to support it. Glass [1992] has noted that non-triviality does not necessarily correspond to task complexity. Second, it had to be challenging enough to engage both expert and novice subjects. Third, it had to be a realistic task. Various researchers in management information systems have warned about the dangers of using unrealistic tasks in experimental designs [Jarvenpaa, Dickson and DeSanctis, 1985; Benbasat, 1989]. While it was not the intention to use completely new task material, it was made imperative by the fact that task material used in prior studies was either not available or did not meet the criteria specified above. Generally, the task material used in the study of the composition of financial expertise [e.g., Bouwman, 1990] and its decision processes [e.g., Bouwman, 1983] was found to be too artificial and trivial to meet the requirements for a KBS. Task material from field studies in accounting of the loan granting and bankruptcy prediction tasks [e.g., Danos, Holt and Imhoff, 1989] was generally not readily available, possibly due to confidentiality reasons.

Initially, case problems in various texts of financial accounting [Stickney, 1990; Foster, 1986; and Bernstein, 1989] and managerial finance [Butters, Fruhan, Mullins and Piper, 1981] were reviewed and evaluated to select an appropriate industry and to determine the minimal set of information that would have to be included in a comprehensive case. Based on this, the high-technology computer manufacturing and retail industry was selected as the context for the case. Using the Computer Industry Case Analysis [Stickney, 1990, p. C-65], the Digital Equipment Case [ibid, p. AR-199], and the Tandy Corporation Case [Bernstein, 1989] as a guide, the financial statements and annual reports of various firms in this industry were sampled and evaluated using
a CD-ROM based financial database. Only companies listed on the New York and American stock exchanges were considered in this evaluation. This was because of the limited number of Canadian companies in this industry. As well, it was felt that by using a disguised foreign company the chances of biases caused by some subjects being familiar with the case would also be minimized.

Of the various companies, one was selected (Tandy Corporation) to provide the basis for the case and was disguised as Vancouver-based Canacom Corporation. Complete annual reports and market reports of the company for a period of ten years between 1978-1988 were obtained and used as the basis for the development of the case. Under the guidance of an accounting professor who teaches financial analysis, the financial statements were reorganized to be in the format prescribed for Canadian companies. As well, other information was modified to "Canadianize" the case and to minimize the time required to read and understand it. Careful attention was paid to the information cues that were to be provided, such as the fact that the auditor's report of the company had yielded an unqualified opinion in the last five years, etc. Appendix 2 presents a copy of the case developed together with the financial statements and other experimental instructions.

The case was then refined and validated iteratively by having two doctoral students in accounting, two chartered accounting students, and two experienced financial analysts (both of whom would later serve as domain experts in the development of the experimental system) analyze and solve the case. Special attention was paid to the time they took to complete the case, the information cues they used, and their perceptions of the difficulty of the case. Their opinions as to missing information cues that they would like added to the case and information cues that were vague were actively solicited and used to improve the case. For example, it was found that close
to eighty percent of the time spend in completing the case was used to compute the various ratios that were required. While the four students did not particularly mind this and generally got straight down to computing the ratios, both the experienced analysts minimized the amount of effort they spent doing this computations. They suggested that a complete set of ratios should be provided as part of the case as virtually all organizations in industry used financial accounting packages and spreadsheets to compute them. This led to the development of a comprehensive set of financial ratios which were subsequently added to the case. Four iterations involving the two financial analysts and the accounting professor were needed to complete this set of ratios. These iterations were necessary to resolve differences in opinion as to which ratios had to be included, what each ratio was to be called, and exactly how each ratio was to be computed. Ratios were computed for a five year period (see Appendix 2). Another three suggestions that were incorporated into the case include the addition of the common-size financial statement ratios, the ratios for the competitor firm, and the industry composites. This ensured that the case contained all the information necessary to perform the three types of comparisons that are used in financial analysis: trend comparisons, comparisons to competitors, and comparisons to industry averages. The Standard Industry Code (SIC) of the real company on which the case is based was used to obtain these industry composites. Considering that the company participates in the both the computer manufacturing and retailing segments, the composites of both these industry segments were included. The criteria used to select the competitor firm (Apple Corporation) included: the same approximate balance between computer manufacturing and retail operations, roughly the same overall scale of operations, and similarity in sales strategy (both used their own chains of retail stores to market their products).
4.2.2 Development of the FINALYZER-XS Experimental System

Considering that the simulation approach was being used, it was imperative that the system developed had to completely cover all aspects of the experimental case developed. Knowledge acquisition was therefore a critical aspect of the system development. It had to adequately elicit all the expertise that human experts utilized to completely analyze the Canacom case. As well, users had to be convinced that they were interacting with a "true" KBS. Failure to do this would mean that users' behavior in the use of the system would be biased and would therefore compromise the goals of the research. As user perceptions of system "expertise" are based primarily on the information cues provided by the user-system dialogue [Einhorn and Hogarth, 1986], interface design was the second major aspect in the development of the system. While knowledge acquisition and interface design were handled separately, and are therefore discussed in separate sections below, it was decided that both the domain expertise and the interaction sequence of the system would be modelled on the decision process obtained from an analysis of concurrent verbal protocols [Ericsson and Simon [1984] elicited from a human expert in financial analysis. This approach is similar to that advanced by Bouwman [1983] who argued that computer programs could be made more "human-like" by basing them on human diagnostic behaviour. Considering that none of the subjects in the study would have prior experience with the use of a financial KBS but most would have interacted with human experts in financial analysis, it was felt that this approach to the systems development would improve users' perceptions of the validity and usability of the system. Therefore, the first step in the development of the system was to collect and analyze the verbal protocols. This is discussed next.
4.2.2.1 Decision Process Used in Financial Analysis

The following is the decision process of an experienced financial analyst evaluating the financial statements of a company to determine an acceptable loan size and to predict its future performance. It was derived from an analysis of concurrent protocols that were collected, using neutral probes [Ericsson and Simon, 1984], as the analyst performed the financial analysis task. The analyst, a partner in a medium sized accounting firm, has been a chartered accountant for twenty years. The steps comprising the decision process were elicited by using the feedforward-feedback conceptualization of the user-KBS interaction, as discussed in Chapter 3, to code the verbal protocols. According to this conceptualization, the interaction is viewed as being analogous to an alternating series of steps involving the system exchanging information with the user spaced by the system performing a particular operation (See Figure 3.2). The steps as viewed according to this conceptualization are highlighted below in bold.

Step 1: Compute a profitability ratio, initially the return on investment (ROI): **information exchange (input)**

Step 2: Evaluate it in terms of trends and possible qualitative factors: **system operation**

Step 3: Form conclusions as to profitability and make a decision as to the need for further profitability analysis. If yes, decide on another ratio and go to Step 1: **information exchange (outcome)**

Step 4: Compute a leverage ratio, initially the debt-equity ratio: **information exchange (input)**

Step 5: Evaluate in terms of trends and possible qualitative factors: **system operation**

Step 6: Form conclusions as to leverage and make a decision as to the need for further leverage analysis. If yes, decide on another ratio and go to Step 4: **information exchange (outcome)**

Step 7: Compute a liquidity ratio, initially the quick ratio: **information exchange (input)**
Step 8: Evaluate in terms of trends and possible qualitative factors: system operation

Step 9: Form conclusions as to liquidity and make a decision as to the need for further liquidity analysis. If yes, decide on another ratio and go to Step 7: information exchange (outcome)

Step 10: Compute a market value ratio, initially the price-earnings (P/E) ratio: information exchange (input)

Step 11: Evaluate in terms of trends, market risks, and other possible qualitative factors, including the impact on return, leverage and cash flow: system operation

Step 12: Form conclusions as to market value and make a decision as to the need for further market value analysis. If yes, decide on another ratio or risk factor and go to Step 10: information exchange (outcome)

Step 13: Compute a funds flow ratio or perform a funds flow item comparison: information exchange (input)

Step 14: Evaluate it in terms of trends, risks, and other possible qualitative factors, including the impact on return, leverage and liquidity: system operation

Step 15: Form conclusions as to funds flow and make a decision as to the need for further funds flow analysis. If yes, decide on another ratio or comparison and go to Step 13: information exchange (outcome)

Step 16: Select a common-size financial statement of the company, initially the common-size income statement: information exchange (input)

Step 17: Evaluate the trends of the individual items both in relation to one another and to other possible qualitative factors: system operation

Step 18: Form conclusions as to the strengths and weaknesses of the items and make a decision as to the need for further common-size and trend analysis. If yes, select the common-size balance sheet and go to Step 16: information exchange (outcome)

Step 19: Select for consideration one of the specific judgmental tasks that has to be performed: information exchange (input)
Step 20: Consider the combined effect of all the financial analysis conclusions made earlier in relation to this specific judgment task: **system operation**

Step 21: Generate the judgment. Decide if another judgment is required, if yes go to step 19: **information exchange (outcome).**

This model of the decision process served as the basis of a modular structure comprising the types of financial analysis that the experimental system was to perform (See Figure 4.1). The protocols revealed that the analyst performed seven different types of analysis: leverage analysis, liquidity analysis, profitability analysis, market value analysis, funds flow analysis, common-size income statement analysis, and common-size balance sheet analysis. As well, each of these analyses was performed independently in a sequential manner. The combined impact of the various analyses was only considered at the end of the process when each of the specific judgement tasks was resolved (Steps 19 through 21 above). This modular structure served as a guide to both the manner in which the knowledge acquisition activities were carried out as well as for the internal design of the system.

The design of the sequence of the experimental system's screens was modelled directly on the decision process depicted above. Note that steps 1, 4, 7, 10, 13, 16 and 19 represent information exchanges where the system communicates with the user about the inputs that are to be used to perform a particular analysis. Considering that these information exchanges deal with input information and occur before a particular analysis is performed, they can be viewed as being feedforward steps. Steps 2, 5, 8, 11, 14, 17 and 20 are system operations where the system "goes away" from the control of the user to perform an action, i.e., a particular analysis. Finally, steps 3, 6, 9, 12, 15, 18 and 21 are information exchanges where the system presents its conclusions and
recommendations to the user. These can be considered to be feedback steps as they relate to the exchange of output information and occur subsequent to a particular analysis being performed by the system. The interaction can therefore be viewed as being comprised of three-step cycles, one for each of the seven types of analysis performed. Each cycle involves starting with an information exchange about the inputs that are to be used, going on to the execution of a particular system operation, and ending with the system and the user exchanging information about the outcomes of
the operation that the system performed. As can be seen in Figure 4.1, for each of the seven types of analysis that FINALYZER-XS performed three different kinds of screens were developed to represent this three-step cycle: feedforward screens, system operation screens, and feedback screens. The feedforward screens listed all the inputs, in the form of ratios and comparison procedures, that the system was to use together with the following message: "All the following inputs will be used by the system as part of its analysis......". The system operation screens comprised two screens presented sequentially. The first presented a short message such as "Computing asset utilization and profitability ratios......" and was displayed for about three seconds. Its objective was to give users the impression that the system was actually performing the computations. The second screen displayed the tables of ratios that had been computed and to which the system was applying its financial expertise. Finally, the feedback screens listed the various conclusions reached by the system together with the message "The following conclusions have been reached by the system......" Appendix 6 presents these three kinds of screens for all the analysis modules of the experimental system.

The verbal protocols collected also served as the basis for the composition of the various screens. For example, conscious effort was made to ensure that the outcomes or conclusions presented in the feedback screens were similar to, as well as couched in the same language, as those used by the domain expert. The following are some examples extracted from the protocols collected: at Step 2 - "Has produced a respectable return on equity (ROE) in 3 of 5 years"; at Step 5 - "Has leveraged close to 1 to 1, and is susceptible to a recession", and "The ROE is so steady because of the low debt-equity ratio"; and at Step 8 - "The repayment structure will have to reflect that liquidity will be low in the initial two years."
4.2.2.2 Interface Design Issues

All of the screens comprising the FINALYZER-XS simulation were designed by the researcher. These were then implemented by a programmer using the Windows 3.0 [Microsoft, 1990] software running in a DOS-environment on a 33 MegaHertz 80386 microcomputer. A mouse-driven, multi-window interface was selected over a line-at-a-time, command language type interface for two reasons. First, it was necessary to make the system as easy-to-use as possible. As some of the subjects would have no prior experience in the use of computer interfaces, it was felt that a mouse-driven, multi-window interface would be easier to learn, easier to use, and less prone to user errors [see Majchrzak, et al., 1987 for a summary of this research]. Second, the mouse-driven, multi-window style has recently become the interface of choice for the bulk of current knowledge-based system applications. Virtually all of the leading high-end KBS development environments utilize it. For example, the personal computer version of NEXPERT Object [Neuron Data, 1991] offers such a mouse-driven, multi-windows front-end to its knowledge-base based on the Windows 3.0 software. Along these same lines, Jones [1990] argues that while in the 1970's the user interface of a decision support system generally consisted of some form of line-at-a-time dialogue with the computer, beginning in the mid 1980's direct manipulation interfaces with mouse-driven, icon-based action languages and multi-window presentation languages, are becoming the norm. He goes on to argue that the growing availability of this interface style will make it a simple necessity in future decision support systems.

In an effort to keep the interface as simple as possible only two types of iconic symbols were utilized as part of the action language by which users communicated with the system. These icons were the radio button and the push button [Borland --- Whitewater Resource Toolkit, 1990]. The
feedback screens presented in Appendix 6 provides examples of both these two icons. Users utilized radio buttons to select particular items from among a set of options, such as input ratios, system conclusions, or types of analysis. As well, by clicking on one of a string of seven radio buttons that comprised a seven-point Likert-type scale, users used the radio buttons to specify their level of agreement with system conclusions. Push buttons were used to switch from one screen to another (screen control), to trigger the start of a particular procedure or analysis, and to view a particular type of explanation that was provided.

Another critical decision made that influenced the design of the interface was the role the KBS was to play in relation to the user. This is related to the "decision support" versus "decision taking" distinction that was discussed earlier in Section 4.2.3 in relation to currently available decision aids for financial analysis. Considering that the focus of this research was on the user support role as against the user replacement role [Wensley, 1989], the system was designed to be an expert consulting and analysis tool (decision aid) rather than a decision making tool. It aids the user by performing all the various computations required and by providing expert diagnostic conclusions relating to the various aspects of the financial health of a company such as liquidity, capital structure, asset utilization, etc.. It does not provide the user with specific prediction estimates or judgmental decisions that the user may be attempting to resolve, e.g., whether the stock being analyzed should be bought or sold, and whether a loan should be granted to the company whose financial statements were being analyzed.

Another related interface design issue was the control of the user-KBS interaction. It is related to Silver's [1991, pp. 115-121] notion of system restrictiveness, i.e., the degree to which,
and the manner in which, a system limits its users’ decision-making processes to a subset of all possible processes. Three specific models of dialogue control can generally be conceptualized: system-driven, user-driven, and hybrid-control. In a system-driven interaction, the KBS leads the user through the various steps of the financial analysis task in a pre-determined and fixed sequential order. Many systems, especially those that are used in experimental studies such as this, utilize this mode as it facilitates control (especially experimental control) by minimizing user errors, user responsibility and the chance that not all aspects of a particular task may be considered. Some authors have even argued that this is the optimal mode for KBS interfaces because it more closely resembles the manner in which human experts interact with their clients [Coombs and Alty, 1980]. From an experimental control perspective, however, there is the danger that it may cause users to behave "unnaturally" in the performance of the financial analysis task. User-driven interfaces, on the other hand, offer complete flexibility to the users in terms of the kinds of analysis that they wish to perform, the order in which they wish to perform it, and even the total amount of analysis that they wish to perform. FINALYZER-XS was designed to utilize the hybrid-control mode. It offered flexibility in terms of the kinds of analysis the user wanted to undertake. For example, as depicted in Figure 4.1, an Analysis Selection Screen was included that offered users the choice as to the type of analysis they wished to do. Appendix 6 presents the actual screen that was used. On the completion of a particular analysis, the system always returned to this "control" screen for the next selection by the user. Exiting the system, by first switching to the Overall Summary Screen, was treated as one of the choices on this Analysis Selection Screen (see Figure 4.1). However, for the purposes of experimental control, some restrictions had to be placed on the flexibility offered by the Analysis Selection Screen. It was decided that while users would have control over the sequential order in which they performed the various types of analysis, they were required to
complete all the seven types of analysis before they could exit the system through the Overall Summary Screen. This was to ensure consistency in the types of analysis performed by all the subjects.

The requirement that users had to be convinced that they were using a "functional" KBS and not just a simulation, led to various refinements in the interface design. First, the initial Introduction Screen (page 363 of Appendix 6) was modified to include system requests for the names of computer data files from which the system would purportedly obtain: 1) the financial statements of the company to be analyzed, and 2) the industry-specific financial expertise that was to be applied to the financial statements. Since neither of these files were really needed or even existed, hypothetical file names were included as part of the screen: "Cana.KBS" for the financial statements of Canacom Corporation and "SIC6479" for the rules comprising the domain expertise of the computer manufacturing and retail industry. Second, intermediate screens with messages such as "Reading Balance Sheets....", "Reading Income Statements.....", and "Reading Statement of Changes in Financial Position" were displayed for three seconds each to give the impression that the system was actually reading in the financial data or performing some particular computations. Casual exploration with various time intervals and involving the programmer and the researcher was used to decide on the three second display interval for these screens. Further, besides all the above interface design considerations, other aspects of the FINALYZER-XS design, e.g., the format for the presentation of the ratio tables, and the inclusion of a logo screen for the system, etc., were modelled to be similar to that of commercially available DSS-type financial analysis software packages such as FSAP [Stickney, 1990] and FISCAL [Haleyon Group, 1990]. It was felt that this would help increase the realism of the experimental system.
4.2.2.3 Knowledge Acquisition Issues

The modular structure of Figure 4.1 was also used as the basis for the knowledge acquisition activities that were undertaken to complete the experimental system. Knowledge acquisition for each of the seven types of financial analysis was performed independently in a sequential manner. For each of these analysis-types, the appropriate feedforward, system operation, and feedback screens were developed with the help of a team of five experts in financial analysis. The first two of these experts were the same individuals who had earlier been involved in the development and refinement of the Canacom Corporation case. One of them (Expert 1) is a manager with the Investment Management Division of Alberta Treasury, which is responsible for the management of the multi-billion dollar Alberta Heritage Savings Fund. He has a Masters degree in finance, holds the Certified Financial Analyst (CFA) designation, has fifteen years experience in corporate lending and investment management, and is a past-president of the Edmonton chapter of the Society for Financial Analysts. The second expert (Expert 2) works as a Senior Equity Analyst in the same organization and is a subordinate of Expert 1. He is both a Chartered Accountant (CA) and a CFA and has fourteen years of experience in financial planning and investment analysis. Considering that his current job requires him to monitor market developments in the high-technology computer manufacturing and retail industry he possesses specialized domain knowledge of that industry. He served as the primary expert in the development of the experimental system. The third expert was the same individual who had earlier provided the concurrent verbal protocols from which the decision process of Section 4.2.2.1 was derived. He is a partner in a medium-sized accounting firm, holds the CA designation, and has twenty years experience, primarily in the preparation and analytical review of financial statements. The fourth and fifth experts were recruited from the banking sector to provide a corporate lending perspective. This ensured that the expert team
comprised expertise of all the three primary areas in which financial statement analysis is heavily used: commercial lending, investment management, and analytical review in auditing. Expert 4 currently serves as the vice-president in-charge of corporate lending at the Canadian Western Bank. He holds a Bachelors degree in the physical sciences and has twenty-three years of experience in commercial lending at all levels of the corporate hierarchy. Expert 5 is a subordinate of Expert 4, holds the CFA designation and possesses twelve years of experience in commercial lending at two banks.

For each of the seven types of financial analysis, knowledge acquisition generally involved obtaining the expert team's consensus on the composition of the feedforward, system operation, and feedback screens. In this sense, the modular structure presented in Figure 4.1 greatly facilitated the knowledge acquisition. However, it was first necessary to validate the modular structure. For this purpose, two more sets of concurrent verbal protocols were collected. Experts 2 and 5 provided these protocols. These were then analyzed by flowcharting the decision processes used. This was done at the same level of analysis as the decision process that is summarized in Section 4.2.2.1. It was found that these experts generally used a similar decision process. They performed each of the same seven types of analysis independently, however, the order in which they performed them varied. While this validated the seven types of analysis included in the modular structure, it also made the case for flexibility in the design of the system in relation to the order in which the various analyses could be performed. There were also some minor differences in the classification and the terminology used for the seven types of analysis. For example, expert 5 performed profitability analysis separately from asset utilization analysis and viewed it as being distinct type of analysis. Another difference was in the use of cash flow analysis. Similar to expert 3 who provided the
earlier protocol, expert 2 placed significant emphasis on it and used cash flow ratios as part of each of the seven types of analysis. Expert 5, however, viewed it as being strictly a subset of funds flow analysis. These two differences reflected varying levels of commitment to the use of: 1) analysis that relates return on investment to asset turnover, and 2) cash flow analysis. Such differences of opinion were generally resolved by consulting other experts and by consulting the accounting professor who helped design the Canacom design. In some situations where two different options were just as valid, the option favoured by of the primary expert (expert 2) was selected.

The next step involved designing the composition of the feedforward, feedback, and system operation screens. It was decided that for each of the seven types of financial analysis, tables of the relevant ratios would be used as the system operation screens. While these tables had been developed earlier as part of the development of the Canacom case, the five experts reviewed them and all their suggestions were incorporated into the revised tables. The bulk of these suggestions related to the addition of particular ratios. The resulting tables can be viewed as being comprehensive collections of ratios that are required to perform any of the analysis. This was important as it reinforced user perceptions of the completeness of the experimental system. During the subsequent data collection stage, none of the subjects complained about some particular ratio being unavailable. Next, the feedforward screens were developed. Considering that these screens were to display lists of the inputs that the system used in performing a particular analysis, they could be obtained in the first instance from the tables of ratios that comprised the system operation screens. The researcher did this for all seven of the feedforward screens initially and, just as with the system operation screens, got each of the five experts to review them. There were few changes that were required by the experts for these screens. Note that the expert team never met as a group
for these review sessions, which were generally conducted individually with each expert by the researcher. However, there were instances when the researcher met experts 1 and 2 jointly as they worked in the same office. This was not the case, however, for experts 4 and 5 although they too worked at the same place.

The development of the feedback screens was more complicated and required much more of the experts' time. This was because the experts had to apply their expertise in solving the case to generate the conclusions that were to be included in the screens. Knowledge acquisition was performed one module at a time, starting with liquidity analysis, and used a variation of the Delphi technique [Helmer and Rescher, 1959]. The experts were given the complete Canacom case and told to analyze it to generate conclusions relating to one of the modules. They were also asked to provide reasons that explained the conclusions they reached. Three of the experts preferred doing this without the researcher being present and mailed out their responses to the researcher. The other two experts did not mind being "put on the spot" and generally analyzed the case in the presence of the researcher to produce their conclusions. They generally provided their conclusions and their rationale in verbal form. These were taped and transcribed. For each module, the researcher compiled all the conclusions provided by the experts and together with the primary expert generated a combined list. As the objective of this compilation was to ensure that the combined list of conclusions was a comprehensive set, very few conclusions were dropped. These were then circulated back to the five experts for their evaluation together with the reasons provided by all five experts for the conclusions. The experts' evaluations of these were generally obtained by the researcher over the phone. Considering that 1) the compilation process used to generate the combined list was "inclusive", 2) no ranking of the conclusions was attempted, 3) the reasons for
each conclusion included in the list were provided, and 4) the names of the experts from whom each conclusion originated was not revealed, experts seldom disagreed with the contents of the combined list and consensus was generally easily reached. However, they commonly provided suggestions as to how the conclusions could be further streamlined or structured. Based on these, the researcher generated a final set of conclusions which were then incorporated into the design of the feedback screens. This process was repeated for all seven of the analysis modules of FINALYZER-XS and took approximately four months to complete. The fact that it was done one module at a time and that experts received the combined list of conclusions for their review, helped to ensure that the motivation of the experts remained high. As each expert knew that the other team members were also performing the same task, they were always keen to know about the conclusions that were generated by the other team members.

On the completion of knowledge acquisition for all the screens (see Appendix 6), a prototype version of FINALYZER-XS was implemented. Only experts 2 and 5 participated actively in the refinement of this prototype. Some of the design issues that had to be resolved at this stage included the number of conclusions to be included on each feedback screen, the layout of each type of screen, and the specific wording used for the conclusions. For example, a conscious effort was made to present an objective and "balanced" view in the feedback screens by incorporating both positive and negative conclusions relating to the Canacom case. Even in the design of the Overall Summary Screen (see Figure 4.1 and Appendix 6) an equal number of positive and negative evaluations were included. Silver [1991, p. 162] calls this the concept of informative decisional guidance, i.e., the system provides the pertinent information that enlightens the decision-makers judgment, without suggesting what judgment to make or how to act.
Finally, two professors in accounting, three doctoral students in finance and accounting, and two junior financial analysts who worked with the primary expert were recruited to help in the refinement process. Their use of the prototype helped to establish its face validity, especially in relation to the quality of its "expertise". These pilot users were also questioned after they had used the system to determine if they were able to detect the absence of a truly functional KBS underlying the FINALYZER-XS interface. None of them was able to detect it. The concern relating to the level of expertise displayed by the system was a critical factor and much attention was paid to it during the entire knowledge acquisition process. It was assumed that the knowledge acquisition would not be complete until the system could convince its users of its expertise, especially in relation to the range of inputs it used and the conclusions it produced. An assessment of the expertise of the final version of the experimental system was also solicited as a manipulation check in a post-study questionnaire that was used in the main study. This took the form of the three items presented in Table 4.1. Seven-point Likert scales were used for measurement and eighty subjects rated the items as follows:

- Item 1: Mean = 1.93 and Standard Deviation = 1.23
- Item 2: Mean = 2.24 and Standard Deviation = 1.26
- Item 3: Mean = 2.52 and Standard Deviation = 1.69

These results suggest that the system had a high level of content validity, i.e., users were convinced of the expertise displayed by the system. It also implies that knowledge acquisition was successful in capturing the expertise required to solve the Canacom case. The next section discusses the development and validation of the explanations provided by FINALYZER-XS. It represented the most difficult aspect of the development of the experimental system.
1. I am impressed by the level of expertise displayed by FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

2. The quality of financial analysis performed by FINALYZER-XS can be rated as being equivalent to that of the best human experts in the field.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

3. Many of the conclusions and recommendations generated by FINALYZER-XS could only have been produced by the most experienced financial analysts in industry.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

Table 4.1: Items Used to Assess The Expertise of The Experimental System

4.2.2.4 Development of the Explanations Provided by FINALYZER-XS

   Of the five types of explanations that were discussed earlier in Chapters 2 and 3, only three were directly implemented in this research. In line with the hypotheses presented in Chapter 3, the WHAT and WHAT-IF explanations were omitted. The same five experts who were involved in the development of the experimental system assisted in the development of the explanations. Similarly, derivation of the explanations also involved using a variation of the Delphi method [Helmer and Rescher, 1959] to obtain the consensus of the five experts for each explanation. However, the overall procedure followed was different.

   Initially, the verbal protocols, provided earlier in the development of the experimental system by experts 2 and 5, were used to obtain material for the explanations. This was done by combining retrospective protocol analysis [Ericsson and Simon, 1984, p. 149] with the teachback
interview [Johnson and Johnson, 1987] method of knowledge acquisition. Experts 2 and 5 were given their respective protocols in transcribed form, and asked to step through their protocols while thinking aloud about the reasons as to how and why they used each input or reached each conclusion. The researcher used directed probes and the ethnographic query which is also known as the paraphrasing method [Meyer, Mniszewski, and Peaslee, 1989] in an effort to focus the verbalizations on specific explanations. As well, these retrospective verbalizations were taped by the researcher and subsequently analyzed. This analysis formed the basis for the next meetings, where the researcher presented or "taught-back" to the experts, his understanding of their reasons as to why and how they used each input or reached each conclusion. During these presentations, the experts often corrected the researcher whenever they disagreed with his assessment of their reasons. This two-step procedure, while sharpening the researcher's understanding of the task expertise, yielded rich material from which the researcher developed an initial set of explanations both for the inputs included on the feedforward screens and for the conclusions presented on the feedback screens. Considering that the current knowledge acquisition literature provides no guidelines as to how expertise for KBS explanations should be elicited, this combination of retrospective protocol analysis and the teachback interview method was found to be very useful. Other material from secondary sources, such as various textbooks on financial analysis and discussions with the other three domains experts, also helped the researcher to formalize the initial set of explanations.

Next, the Why, How, and Strategic explanations for both the feedforward and feedback screens of liquidity analysis (see Appendix 6), were given to all five domain experts for review, improvements, and comments. The experts evaluated these independently and provided written
responses as to the changes they would like made to the explanations. Whenever the researcher was unclear about the reasons for any particular change suggested by any of the experts, these reasons were obtained over the phone from the appropriate expert. Based on all these suggestions, the explanations were improved and consolidated into a new set by the researcher. These were then circulated back to the five experts together with information as to the changes made and the reasons for each major change. The experts then provided further suggestions which formed the basis for the next iteration. Between three to six iterations were necessary to obtain consensus, yielding a complete set of explanations for liquidity analysis. The whole process was then repeated for each of the six other types of financial analysis that comprised the experimental system. While most of the changes suggested by the experts related to the contents of the explanations, others related to presentation format and the grammatical considerations. One major change that was suggested and incorporated related to the presentation of the Strategic explanation. The experts felt that the Strategic explanations would be more useful if presented in graphical format as compared to the text format.

The experts participated unevenly in the iterative Delphi procedure and most generally found it to be a tedious exercise. Two of the experts opted out after the second iteration for the last three of the analyses as they felt that the explanations at that stage were satisfactory with them. However, the process was continued with the remaining experts as it was critical to the study that the explanations reflected a high level of expertise. As with the development of the experimental system, Expert 2 played a major role in the refinement of the explanations. In an effort to keep the experts motivated two changes were made to the procedure. First, the explanations were incorporated into the experimental system after the second iteration and the implemented prototype
was used in subsequent iterations. Second, experts were allowed to "sign-off" on any particular explanation which they felt was in acceptable form. These changes were very successful in increasing the motivation of the experts. The explanations were implemented into the experimental system by the researcher using the Notepad and Paintbrush accessories of Windows 3.1. This facilitated the improvement of the explanations at the end of each iteration. Approximately three and a half months were required to complete both the development and implementation of all 234 of the explanations that were required.

The Notepad and Paintbrush explanation files were linked to the appropriate feedforward and feedback screens of the experimental system by incorporating buttons for accessing these explanations at the bottom left corner of these screens. As can be seen on the screens displayed in Appendix 6, there were separate buttons for each of the three kinds of explanations and the explanations were not provided automatically to the users. Rather, users had to use the mouse input device to explicitly click on the button corresponding to the type of explanation they wished to consider. This corresponds to the passive accessibility format that was discussed in Chapter 2. Each explanation was displayed in its own distinct window when requested and only one explanation could be viewed at any one time. The three explanation buttons were presented side-by-side in the same order on both the feedforward and feedback screens: the Why button on the left, the How button in the middle, and the Strategic button on the right. While counter-balancing schemes for this presentation order were considered for the purposes of controlling for ordering effects, it was rejected as it was felt that it would distract or confuse users as they interacted with the system to complete the experimental task. As well, it would have adversely affected the realism of the experimental system.
4.3 Validation of the Explanations Developed

In an effort to assess the face validity of the explanations that were incorporated into the prototype, two accounting professors and three doctoral students used the system together with the explanations. The informal assessments that they provided were positive. The explanations were then validated in a more formal pilot test using a small sample of individuals familiar with financial analysis. This was necessary as the explanations developed were the main manipulation used in the research.

The first objective of the pilot study was to ensure that all the explanations developed were adequate in terms of three attributes that were identified as being possible confounding variables on the relationship between the provision of explanations and their use by users: 1) readability, 2) understandability, and 3) definitional accuracy. Readability refers to the correctness of the grammatical structure and vocabulary used to provide an explanation [Kintsch and Vipond, 1979]. It can reasonably be assumed that a low level of explanation readability will directly influence user perceptions of explanation usefulness. The understandability of an explanation refers to the semantics or meanings that users assign to an explanation in relating it to the real world. Users will not, therefore, select explanations that are not understandable to them. Definitional accuracy refers to how faithfully an explanation represents an operationalization of the definition of its class. It is related to users expectations about what they expect to receive when they select a particular explanation for viewing. For example, a user who selects the How explanation for viewing has a certain expectation as to what he or she will receive for it. If the explanation provided does not accurately match this expectation it will not be considered useful by the user. Such expectations for an explanation are a direct function of the definition for the class of explanations to which the
particular explanation belongs. In addition to ensuring that the explanations developed had adequate
levels of readability, understandability, and definitional accuracy, the second objective of the pilot
test was to ensure that their was a reasonable degree of equivalence both between: 1) feedforward
and feedback explanations, and 2) the Why, How, and Strategic explanations. The details and results
of this pilot test are discussed next.

Five graduating students, who were in the final weeks of the Bachelor of Commerce
program at the University of Alberta were recruited. It was required that they be majors in either
accounting or finance and be familiar with financial statement analysis. They were told that they
would be paid $10 an hour for their participation. The first five who volunteered were accepted and
made to fill out a background information questionnaire and a confidentiality form that were
designed for the main study (See Appendix 1). Four were accounting majors who were going on
to study for their Chartered Accountancy examinations, while another was a finance major joining
an insurance firm as an analyst.

The participants were brought together in a seminar room and formally lectured on the
nature of expert systems and their interfaces including the explanation facility. They were
encouraged to ask as many questions as they wished and to learn as much as possible. Next, they
were given a demonstration of the CREDIT-ADVISOR expert system simulation (See Appendix 5)
that was developed to be a tutorial in the main study. They were also given an opportunity to obtain
"hands-on" familiarity with the system to understand how the interface and explanations functioned.
The Canacom case was also provided to them and they were asked to familiarize themselves with
its details. This session lasted about 40 minutes. They were then led to another seminar room and
seated around a VGA computer display screen that was similar to the one that was used in the main study. The seating layout ensured that one person's notes could not be easily viewed by another person. They were then given two information sheets that defined each of the three types of explanations in relation to both the feedforward and feedback screens of the system. These are presented in Appendix 9. They were instructed to read them carefully and to understand the definition of each of these explanations. All questions were answered and any clarifications sought were provided until each participant felt that they understood all the definitions. They were instructed to place the definition sheets on the desks in front of them and were allowed to refer to the definitions as often as they wished. Next, they were given multiple copies of a rating sheet (also provided in Appendix 9) and told that they had to fill one rating sheet for each of the explanations that was to be displayed to them on the computer screen. They then read this rating sheet and it was ascertained that they clearly understood all the items that were included in it.

The rating sheet comprised six items that utilized seven-point, Likert-type scales (see Appendix 9). Items 3 and 4 elicited ratings of the "readability" of the explanations. These measurements of the readability of the explanations were collected for two reasons. First, it was necessary to ensure that all the explanations had an acceptable level of readability. Second, it was critical that the various types of explanations be equivalent in terms of readability, i.e., feedforward explanations were as readable as feedback explanations, and the Why explanation was as readable as both the How and Strategic explanations. This calibration was critical to guard against the possible confounding effects of differing levels of readability among the explanations [Ye, 1990]. The high level of readability of an explanation does not, however, guarantee that it will understandable to users. Therefore, items 1 and 6 were developed to elicit ratings of the
"understandability" of the explanations. Considering that the literature was scarce in relation to instruments for the measurement of this understandability construct, an empirical approach that relied largely on the literature on text comprehension was used to develop these items. Items 2 and 5 related to how well the explanations as displayed met the definition of their category as per the definition sheets placed before the participants. Calibration of the content of the explanation types, such as measurements of informational and computational equivalence [Simon, 1978], were not necessary as each of the type of explanations was by definition distinct from the others. While some overlap was to be expected in the contents of the three types of explanations, they certainly could not be viewed as being complete substitutes for one another.

Each of the 159 feedforward explanations and 75 feedback explanations were displayed on the computer screen one at a time in a randomized order. Feedforward explanations were displayed together with the input item (ratio or comparison procedure) that they explained while feedback explanations were displayed together with the conclusion that they explained. Each participant was required to complete one copy of the rating sheet for each explanation displayed. Each explanation was displayed for as long as it took all five of the participants to complete their respective rating sheets. The category of explanations (Why, How and Strategic) to which an explanation belonged was not displayed.

For each explanation that they read, participants initially had to specify on the rating sheet the category of explanations to which that explanation belonged. They had to specify both: 1) if it was a feedforward or feedback explanation, and 2) whether it was a Why, How, or Strategic explanation. They were then immediately told the correct category to which the explanation
belonged and the correctness of each participant's response was ascertained. This had the advantage of allowing the researcher to immediately elicit from a participant the underlying reasons as to why an explanation had been incorrectly classified. However, all explanations were correctly classified by all of the participants. This suggested that the participants could clearly distinguish between the three types of explanations (Why, How, and Strategic) and also between feedforward and feedback explanations. The explanations developed were therefore consistent with the definitions provided for them.

Next, participants rated the particular explanation being displayed before them on the six items on the rating sheet. Finally, they were asked to write at the bottom of their rating sheets their comments and suggestions for improving the particular explanation including aspects of its contents, readability and presentation on the screen. The rating sheets were then collected from the participants before the next explanation was displayed. Considering the tediousness of the task (234 evaluations per person) two separate sessions were required and scheduled on separate days to minimize fatigue. While all five participants were present at the first session, the second session was conducted in two sections due to participant availability constraints. Three of the participants took part in one section and two in the other section. In the latter, one participant was lost due to attrition and replaced with another from the same graduating class with a similar finance major. In total, each participant took approximately seven hours and fifteen minutes to complete the exercise over two days. This included breaks of five minutes each that were given every hour, or at the participants' calling, to reduce fatigue and boredom. At the end, subjects were debriefed, thanked for their participation, reminded about their consent to confidentiality, and paid for their participation.
Table 4.2: Summary Statistics for Explanation Attributes

<table>
<thead>
<tr>
<th>Item 1</th>
<th>Item 6</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 2</th>
<th>Item 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.17</td>
<td>6.04</td>
<td>6.22</td>
<td>6.49</td>
<td>6.18</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.85</td>
<td>0.94</td>
<td>0.93</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>

The 1,170 rating sheets that were collected (234 explanations evaluated by 5 participants) were then analyzed with SYSTAT (1990). Table 4.2 presents the means and standard deviations for each of the six items on the rating sheets. Note that a mean value of 7.0 for each item would signify that the explanations were either completely understandable, readable, or accurate in relation to their respective definitions. The fact that all the mean values were greater than 6.0 suggests that the explanations were easy to read, easy to understand, and represented good operationalizations of their definitions. These mean values for the three attributes of the explanations represent the minimal levels that can be ascribed to the final set of explanations that were incorporated into the experimental system. This is because every explanation that yielded a rating of 5.0 or lower on any of the six items was re-evaluated subsequent to the pilot test and improved further based on the subjective comments provided by subjects at the bottom of each rating sheet. In relation to the understandability attribute, considering that students were used as subjects to provide these ratings, it can reasonably be argued that experts would find the explanations even more easier to understand as they would have a better understanding and knowledge of the financial analysis domain.

Further analysis of the explanations focused on each of the attributes independently.
### Table 4.3: Statistics for the Understandability of Explanations

<table>
<thead>
<tr>
<th>Explanation Type</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why</td>
<td>12.25 (1.42)</td>
<td>11.99 (1.74)</td>
<td>12.12 (1.54)</td>
</tr>
<tr>
<td>How</td>
<td>12.70 (1.40)</td>
<td>12.24 (1.76)</td>
<td>12.47 (1.54)</td>
</tr>
<tr>
<td>Strategic</td>
<td>11.92 (1.83)</td>
<td>11.90 (2.08)</td>
<td>11.91 (1.91)</td>
</tr>
<tr>
<td>Total</td>
<td>12.29 (1.59)</td>
<td>12.05 (1.87)</td>
<td>12.21 (1.69)</td>
</tr>
</tbody>
</table>

### Table 4.4: Statistics for the Readability of Explanations

<table>
<thead>
<tr>
<th>Explanation Type</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why</td>
<td>12.75 (1.34)</td>
<td>12.28 (1.76)</td>
<td>12.51 (1.82)</td>
</tr>
<tr>
<td>How</td>
<td>13.21 (1.07)</td>
<td>12.59 (1.64)</td>
<td>12.90 (1.31)</td>
</tr>
<tr>
<td>Strategic</td>
<td>12.56 (1.68)</td>
<td>12.46 (2.10)</td>
<td>12.51 (1.82)</td>
</tr>
<tr>
<td>Total</td>
<td>12.84 (1.41)</td>
<td>12.44 (1.85)</td>
<td>12.71 (1.57)</td>
</tr>
</tbody>
</table>

### Table 4.5: Statistics for How Accurately the Explanations Reflect Their Definitions

<table>
<thead>
<tr>
<th>Explanation Type</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why</td>
<td>12.37 (1.27)</td>
<td>12.17 (1.63)</td>
<td>12.27 (1.40)</td>
</tr>
<tr>
<td>How</td>
<td>12.91 (1.38)</td>
<td>12.40 (1.49)</td>
<td>12.65 (1.43)</td>
</tr>
<tr>
<td>Strategic</td>
<td>12.04 (1.89)</td>
<td>12.06 (1.97)</td>
<td>12.05 (1.91)</td>
</tr>
<tr>
<td>Total</td>
<td>12.44 (1.57)</td>
<td>12.21 (1.71)</td>
<td>12.37 (1.62)</td>
</tr>
</tbody>
</table>

Legend: The data is in the form - Mean (Standard Deviation)

4.3, 4.4, and 4.5 provide the detailed statistics for each of these attributes. Note that the six items were combined to yield single measurements for each of the three attributes of the explanations. For example, items 3 and 4 were summed to yield a common measure for readability and items 1 and 6 were summed for the measure of explanation understandability. Combining the items in this way...
manner was possible because they utilized a similar scale for data collection. While only the means and standard deviations for the combined variables are presented here in Tables 4.3, 4.4, and 4.5; the detailed statistics for each of the six items are presented as part of Appendix 9. A cursory evaluation of the statistics suggests that the feedforward explanations were generally more readable, easier to understand, and more accurate operationalizations of their definitions, than feedback explanations. Additionally, the How explanation received the highest ratings for readability, understandability, and definitional accuracy, while the Strategic explanation rated the lowest on all three of the attributes.

The statistical significance of these differences was then tested by using the data to run three separate ANOVA models. These are presented in Figure 4.2. For each of the three attributes of the explanations, two-factor ANOVA analysis was performed. The first factor was the type of explanation and it had three discrete levels conforming to the Why, How, and Strategic explanation levels.

Model 1: READABILITY = B₀ + B₁(WHS) + B₂(FFFB) + B₃(WHS*FFFB) + e

Model 2: UNDERSTANDABILITY = B₀ + B₁(WHS) + B₂(FFFB) + B₃(WHS*FFFB) + e

Model 3: DEFINITIONAL ACCURACY = B₀ + B₁(WHS) + B₂(FFFB) + B₃(WHS*FFFB) + e

Legend:
- Bᵣ = Beta Weights
- e = Error Term
- WHS = Why, How, and Strategic Explanation Types
- FFFB = Feedforward or Feedback Explanations

Figure 4.2: ANOVA Models Used to Validate The Explanations
explanations. The second factor had two levels: the feedforward and feedback provision of explanations. Prior to the analysis being conducted, the three dependent variables were evaluated in relation to the assumptions of multivariate normality. The specific tests and procedures used to perform this evaluation of the assumptions underlying the ANOVA model, were similar to that used in the main study and are detailed in Section 7.1 of Chapter 7. The data satisfied all the assumptions with one exception: the assumption of distributional normality [Neter, Wasserman and Kutner, 1985]. As a result, all three of the variables had to be transformed using the natural logarithm algorithm to ensure that they conformed to this critical assumption [Lillefors, 1967; Systat, 1990].

The results of the three ANOVA models are presented in Table 4.6. They reveal that at the 0.05 confidence level there are no statistically significant differences in readability, understandability, and definitional accuracy, both: 1) between the feedforward and feedback explanations, and 2) between the Why, How, and Strategic explanations. As well, none of the interaction effects of all the three models was significant. The p-values for the feedforward and feedback provision of explanations (main effect) were consistently high across all three ANOVA models. This suggests that the null hypotheses, of there being no differences between the two levels of explanation provision, could not be rejected. Further, it meant that for the purposes of this study and from a statistical perspective, it was reasonable to make the assumption that the feedforward and feedback explanations developed were equivalent in terms of readability, understandability, and definitional accuracy. The results for the type of explanation (WHS) main effect, while being similar, are weaker, yielding p-values of 0.097, 0.119, and 0.124 respectively for the three models. Based on these results, it was decided that in the final iteration for improving the explanations, more attention would be paid to improving the readability, understandability and definitional accuracy of
### Table 4.6: ANOVA Results: Validation of Explanations

<table>
<thead>
<tr>
<th>Variables and Effects</th>
<th>DF</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Dependent Variable: Readability of Explanations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Explanation (WHS)</td>
<td>2</td>
<td>1.66</td>
<td>0.097</td>
</tr>
<tr>
<td>Feedforward/Feedback Explanations (FFFB)</td>
<td>1</td>
<td>0.12</td>
<td>0.903</td>
</tr>
<tr>
<td>WHS*FFFB Interaction</td>
<td>2</td>
<td>1.53</td>
<td>0.125</td>
</tr>
<tr>
<td><strong>B. Dependent Variable: Understandability of Explanations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Explanation (WHS)</td>
<td>2</td>
<td>1.56</td>
<td>0.119</td>
</tr>
<tr>
<td>Feedforward/Feedback Explanations (FFFB)</td>
<td>1</td>
<td>0.02</td>
<td>0.985</td>
</tr>
<tr>
<td>WHS*FFFB Interaction</td>
<td>2</td>
<td>0.92</td>
<td>0.359</td>
</tr>
<tr>
<td><strong>C. Dependent Variable: Definitional Accuracy of Explanations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Explanation (WHS)</td>
<td>2</td>
<td>1.54</td>
<td>0.124</td>
</tr>
<tr>
<td>Feedforward/Feedback Explanations (FFFB)</td>
<td>1</td>
<td>0.09</td>
<td>0.930</td>
</tr>
<tr>
<td>WHS*FFFB Interaction</td>
<td>2</td>
<td>0.85</td>
<td>0.399</td>
</tr>
</tbody>
</table>

The improvements were made based on the written subjective comments provided by the five subjects at the bottom of the rating sheets used in the pilot study.
4.4 Summary of the Chapter

This chapter described the various considerations involved in the selection of the task domain and the development and validation of the experimental KBS and its explanations. The next chapter describes the research design and procedure utilized to investigate the research hypotheses of Chapter 3 within the context of the task domain that was selected and the KBS that was developed.
CHAPTER 5: RESEARCH DESIGN & EXPERIMENTAL PROCEDURES

5.0 Introduction

This chapter describes the experiment which was conducted to investigate the hypotheses relating to the determinants and the impact of the use of explanations that were provided by a knowledge-based system. The experimental design and procedures are discussed in detail and the approach taken to data analysis is outlined. The next sections discuss how the various independent and dependent variables were operationalized. The final two sections of the chapter will focus on the experimental procedures utilized and the approaches taken to data analysis.

5.1 Independent Variables

As can be seen in the research model presented in Figure 5.1, this study investigated four factors that influence the use of explanations: explanation provision strategy, user expertise, types of explanations, and the level of user agreement with the system. While the first three were the primary independent variables and were directly manipulated in the study, the level of user agreement was a moderating variable. As well, accuracy of judgmental decision-making and user perceptions of usefulness served as the dependent variables for investigating the impact of the use of explanations. The independent variables were operationalized as follows:

5.1.1 Explanation Provision Strategy

As depicted in Table 5.1, explanation provision strategy was decomposed into four treatment conditions by juxtaposing the two conditions (Yes and No) for each of its two levels: the feedback
provision of explanations and the feedforward provision of explanations. These treatment conditions were operationalized by controlling the screens on which buttons for accessing explanations were provided to the subjects by the KBS (For some examples, see the screens that are presented in Appendix 6).

Table 5.1: Explanation Provision Strategies

<table>
<thead>
<tr>
<th>Feedback (FB) Explanations</th>
<th>Feedforward (FF) Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>BOTH</td>
</tr>
<tr>
<td>Yes</td>
<td>ONLY FB</td>
</tr>
<tr>
<td>No</td>
<td>ONLY FF</td>
</tr>
<tr>
<td>No</td>
<td>NONE</td>
</tr>
</tbody>
</table>
As part of its interaction with the user, the KBS exchanged information with the user through two kinds of screens: 1) feedforward screens --- when it was informing the user about the various input's that it would use for its analysis, and was requesting the user's permission to proceed with a particular sub-analysis, and 2) feedback screens --- when it was presenting its conclusions after the completion of the computation and evaluation required for the sub-analysis.

As was depicted in Figure 4.1 of Chapter 4, for each type of sub-analysis that the system performed, the feedforward screen was first presented by the system prior to performing the necessary computation and evaluation. On the completion of this computation and evaluation it presented the feedback screen. Appendix 6 includes all the feedforward and feedback screens that were used for the seven sub-analyses that the KBS performed. Subjects in the "feedforward only" group had explanations made available to them on every "input" screen that they viewed. Subjects in the "feedback only" group could access the explanations made available to them on every "conclusion" screen that they viewed. The "both feedforward and feedback" group had explanations provided on both the input and conclusion screens that they viewed. Finally, the "neither feedback nor feedforward" condition was operationalized by excluding access to explanations from all of the screens of the system.

It was important to ensure that each explanation that was presented in feedforward form was consistent, in terms of both the effort required to access it and the format in which it was presented on the screen, to its counterpart presented in feedback form. For this reason, all the explanations provided using either of the feedforward or feedback provision strategies were designed to be consistent in both these two respects. As was discussed in Chapter 4 earlier, the differences between them were limited to the differences between the feedforward and feedback cognitive learning
constructs that were discussed earlier: 1) feedforward explanations were not case specific while feedback explanations were focused on case-specific outcomes, 2) feedforward explanations were made available prior to the system performing the relevant financial analysis computation/evaluation while the feedback explanations were presented subsequent to it, and 3) feedforward explanations related to the inputs used in the particular financial analysis computation/evaluation that was to be performed while feedback explanations related to the outcomes of that computation/evaluation.

5.1.2 User Expertise

The novice, apprentice, and expert levels were identified earlier in Chapter 2 as being the three relevant theoretical dimensions of the user expertise construct. However, only two of these levels were measured in this study. These were the two end points of the user expertise continuum; the novice and expert levels. The reason for this is that there are significant measurement difficulties inherent in pinpointing the exact cut-offs for the middle "apprentice" level. By focusing on the end levels a more valid operationalization would result. It should be noted, however, that the disadvantage of this is that the results of the study would not be generalizable to the whole user expertise construct. Therefore, two distinct groups of subjects were carefully selected to maximize the differences between them on the measurement scales used to operationalize user expertise, as discussed in the next paragraph. This was facilitated by the fact that the procedures required to recruit expert subjects differed significantly from those needed for novice subjects.

Bedard [1989, p. 114] asserts that as the construct of expertise is impossible to observe, it should be operationalized using multiple measures representing observable criteria such as: years of experience, educational and professional qualifications, evaluation reviews, and the results of peer
reviews. Of these, and because participation in the study was voluntary, only the first two were used. Novice subjects were recruited from amongst accounting and finance students who were familiar with the declarative knowledge and basic procedures of financial analysis. Subjects had to have taken the equivalent of at least one introductory-level course directly related to financial analysis, and to have little or no working experience in performing it routinely. Subjects recruited included undergraduate and graduate students at the University of British Columbia and the University of Alberta, and those studying to qualify as chartered accountants (CA) and certified general accountants (CGA) in Canada. Expert subjects were recruited from amongst experienced financial executives and loan analysts from various financial institutions in Vancouver and Edmonton. As participation was voluntary, conscious effort was made to select those who possessed some related professional qualifications beyond the undergraduate degree, such as the CA and certified financial analyst (CFA) designations. As well, they had to possess at least three years of post-qualifying, working experience that directly related to financial analysis.

5.1.3 Types of Explanations

All three of the Why, How and Strategic explanations were used in the study. Chapter 4 described the manner in which they were developed and operationalized in relation to the definitions developed for them in Chapter 3. It also described the pilot test that was used to validate them in terms of readability, understandability and definitional accuracy. All three of the explanations were always made available simultaneously, and users were free to use as many of these explanations as they wished, as well as in any order that they choose.
5.1.4 Level of User Agreement

No attempt was made to manipulate or control this moderating variable. Rather, users' agreements with the conclusions presented by the KBS were captured for evaluating the hypothesized: 1) inverse relationship between the level of user agreement and the use of explanations, and 2) moderating influence of user agreement on the relationship between user expertise and the use of explanations. Users were asked to specify their level of agreement with each conclusion that the system presented to them on a single-item, seven-point Likert-type scale. This measurement was taken after the user had evaluated a particular system conclusion, but prior to his or her viewing any explanations related to that conclusion. There were 25 such measurements taken from each subject, one for each conclusion that was presented. In the interest of maintaining consistency of both the system interface and of user effort in using the system, subjects in all the treatment groups provided this data. These included those who had no explanations made available to them. While more detailed multi-item scales for measuring the level of agreement with a system conclusion could have provided a more reliable measure, the development and use of such an instrument was not considered feasible. The time required for a subject to complete such an instrument for each of the 25 conclusions would have been prohibitive and would have reduced user perceptions of the realism of the experimental system and the problem solving context which were used in the study.

5.2 Dependent Variables

There were three primary dependent variables: the use of explanations provided by the KBS, the accuracy of judgmental decision making, and user perceptions of usefulness. All three of these are multi-dimensional constructs and were operationalized using multiple measures.
5.2.1 Use of the Explanations

The explanation selection behavior of users was used as a surrogate for measuring the use of explanations. For example, if a user selected a particular explanation for viewing, it was taken to mean that the particular explanation had been cognitively used by the user. This distinction between the cognitive use of explanatory information and the express behavior of selecting it for viewing, as well as the advantages and disadvantages of using the latter as a surrogate for measuring the former, were discussed in Chapter 3.

The use of explanations measure was derived from the computer logs of the users' interaction with the KBS. The logs provided counts for feedforward explanations used, feedback explanations used, why explanations used, how explanations used, and strategic explanations used.
explanations used, as well as separate sub-counts for each of the Why, How, and Strategic explanations used. Figure 5.2 summarizes the breakdown of these counts of explanations usage. Note that the count for total explanations used is comprised of the counts for the feedforward and/or feedback explanations used. As discussed earlier in Section 5.1.1, these were presented on separate screens of the system and some treatment groups did not receive either or both of the feedforward and feedback explanations. These groups therefore had no scores for the use of either or both of the feedforward and feedback explanations. Whenever explanations were provided on a screen, irrespective of whether it was a feedforward or feedback screen, three types of explanations were provided together (see Appendix 7). These were the Why, How and Strategic explanations. Chapter 4 discussed how these explanations were designed as part of the overall development of the experimental system and provided the results of a pilot test undertaken to assess their comparative readability, understandability, and definitional accuracy.

The three levels of counts of explanation usage had to be further transformed before they could be used in the data analysis. This was necessitated by a difference between the total number of instances of feedforward explanations and the total number of instances of feedback explanations that were made available. Feedforward explanations were made available in 53 instances while feedback explanations in 25. Considering that in financial analysis a large number of inputs get combined to yield a smaller set of conclusions, it was inevitable that there were a greater number of feedforward explanations as compared to feedback explanations. Their exact numbers were determined by the requirement that the explanation facility of the experimental system had to adequately cover all the various aspects of the financial analysis task. This meant that comparing the absolute counts of explanations used would be biased by the difference in the total number of
explanations provided for the two categories of explanations. As a result, the explanation usage counts were converted into proportions of the total number of explanations that were provided for each category. This approach is consistent with other studies that have investigated the more general problem of use made of information provided by a decision support system (see for example Todd & Benbasat, 1991). Table 5.2 presents the denominators used in the computation of these proportions of the use of explanations. These numbers represent the total number of explanations that were provided by the KBS for each treatment condition that was discussed in Section 5.1.1.

Table 5.2: Denominators Used for Computing Explanation Usage Proportions

<table>
<thead>
<tr>
<th>Measures of Explanations Provided</th>
<th>NONE</th>
<th>FF ONLY</th>
<th>FB ONLY</th>
<th>BOTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Explanations Provided</td>
<td>-</td>
<td>159</td>
<td>75</td>
<td>234</td>
</tr>
<tr>
<td>Feedforward Explanations Provided</td>
<td>-</td>
<td>159</td>
<td>-</td>
<td>159</td>
</tr>
<tr>
<td>FF-WHY Provided</td>
<td>-</td>
<td>53</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>FF-HOW Provided</td>
<td>-</td>
<td>53</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>FF-STRATEGIC Provided</td>
<td>-</td>
<td>53</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>Feedback Explanations Provided</td>
<td>-</td>
<td>-</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>FB-WHY Provided</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>FB-HOW Provided</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>FB-STRATEGIC Provided</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
In summary, the three levels of measures for the use of explanations were obtained and analyzed separately. These measures took the form of ratio-type data of the proportions of explanations used. It should also be noted that while these measurements of the use of explanations represented dependent variables in the study of the factors that influenced the use of explanations, (see the research model of Figure 5.1 at the start of this chapter), they also served as the independent variables in the study of the effects of explanation use on the two dependent variables that are discussed next: the accuracy of judgmental decision making and users perceptions of usefulness.

5.2.2 The Accuracy of Judgmental Decision Making

The task used in the study involved making judgments under conditions of uncertainty [Kahneman, Slovic and Tversky, 1982] aided by the use of a diagnostic KBS for evaluating the financial state of a company. Users of financial statements routinely make a variety of such judgments in financial decision situations. These judgments can generally be classified into the evaluative and predictive categories proposed by Hogarth [1987]. Evaluative judgments are seen as reflecting individual preferences while predictive judgments represent the combination of a set of evaluative judgments into predictions under conditions of uncertainty. Subjects were asked to make six evaluative judgments and two predictive judgments. The objective was to obtain multiple measures for the two judgment categories, as well as to ensure that all the subjects consistently considered all aspects of the problem solving case used in the experiment.

The six evaluative judgments related to the: 1) liquidity, 2) capital structure, 3) asset utilization and profitability, 4) market valuation, 5) financial management, and 6) operating
management, aspects of the experimental case. Each of these measures was collected using single-item ten-point Likert type scales yielding ordinal data. The two predictive judgments were predictions of the net income in the coming year and the optimal loan size that would be appropriate for the company in the experimental case. These measures were collected as ratio-type data in the form of amounts in millions of dollars. The Judgment Recording Sheets included in the experimental task material presented in Appendix 2 were used to collect all these judgments.

The accuracy of all the eight judgments was determined in relation to a set of "correct" consensus estimates agreed upon by a panel of five expert judges. A variation of the Delphi method [Helmer and Rescher, 1959] was used to obtain these estimates. This involved circulating back to each of the judges a combined list of all the judgments initially made individually by each judge. Each judge could then change his initial estimates and these formed the basis for the next round of evaluation. As there was minimal variation in the judgments, especially for the six evaluative judgments, only two rounds of evaluation were needed to reach the consensus set of estimates. As these were the same judges who participated in the development of the experimental system (as discussed in Chapter 4), the final estimates were agreed upon at a lunch meeting held at the end of the development of the system. Thus, there was an extensive exchange of ideas, opinions, and justifications between the judges prior to their agreement on the final set. A description of the qualifications and competence of these panel of judges and a more detailed description of the procedure used was given in Chapter 4.

Subjects’ estimates of each judgment were compared to the correct consensus score and a measure of the absolute deviation obtained as a measure of its accuracy. This is similar to the
accuracy and bias measures, such as the mean absolute error, that have been suggested for such financial analysis judgments [Foster, 1986]. The absolute deviations for the six evaluative judgments were summed for each subject to yield an overall accuracy measure for the evaluative judgment category. The same was done for the two predictive judgments with one difference. The absolute deviation for each judgment was first converted to be a proportion of the value of the correct consensus score. Only then were the deviations of the two judgments summed to yield one accuracy measure for predictive judgments. This was necessary to eliminate differences in the size of the deviations caused by differences in the size of the correct scores [Foster, 1986]. This procedure amounts to ensuring that there was equivalence in the scales being combined.

In summary, deviation scores were used as measurements for accuracy. As well, there were two composite measures, one for evaluative judgments and the other for predictive judgments. Considering the considerable differences between the nature of these two categories of judgments and the fact that one was measured using ordinal data and the other using ratio data they were assessed separately.

5.2.3 Perceptions of Usefulness

Two perceptions of usefulness were measured. One focused on the usefulness of the overall knowledge-based system that the subjects used in the study. The other focused on the usefulness of the explanations that were provided by the system. It was necessary to separate the measurement of the two as they can be viewed as being at two separate levels of analysis, and little is known currently about how the perception of the usefulness of one aspect of a system’s interface impacts its overall perception of usefulness.
5.2.3.1 Perceived Usefulness of the System

This dependent variable was included to test the hypothesized effect of the use of explanations on the degree to which users perceived that using the system providing the explanations enhanced their task performance. Capitalizing on the cumulative tradition [Keen, 1980] of recent information systems studies of system usefulness and the fact that measurement instruments with high degrees of validity and reliability have been developed [Moore & Benbasat, 1991; and Davis, 1986], a ten-item instrument was designed to measure this construct based on these prior studies.

1. Using FINALYZER-XS enabled me to accomplish the financial analysis task more quickly.
2. Using FINALYZER-XS improved the quality of the analysis I performed.
3. Using FINALYZER-XS made the financial analysis task easier to do.
4. Using FINALYZER-XS enhanced my effectiveness in completing the financial analysis task.
5. Using FINALYZER-XS gave me more control over the financial analysis task.
6. Using FINALYZER-XS increased my productivity.
7. Using FINALYZER-XS allowed me to accomplish more analysis than would otherwise have been possible.
8. The use of FINALYZER-XS greatly enhanced the quality of my judgements.
9. FINALYZER-XS conveniently supported all the various types of analysis required to complete the judgmental decision making tasks.
10. Overall, I found FINALYZER-XS useful in analyzing the financial statements.

Table 5.3: Items Used for Measuring Usefulness of the System

Considering that the definition of usefulness in this research was similar to that used by Davis [1986] and to what Moore and Benbasat [1991] term as "relative advantage", a combination of the items on these two instruments were derived and adapted to the context of this study. Table 5.3
presents the items that comprised the instrument. Data was collected in the form of seven-point Likert-type scales. Of the ten items comprising the instrument, items 1, 2, 3, 4, 5, 6, and 10 represent variations adapted from items found on both the Moore & Benbasat and the Davis scales. Item 7 was adapted solely from the Davis scale, while items 8 and 9 were added to reflect two critical aspects of the use of knowledge-based systems for making judgments. Item 8 focuses on the association between the use of a knowledge-based system and the quality of the judgments made using it. This link between the system and the resulting judgments (outputs) is much more direct and evident in this case as compared to the more generalized technological innovations, such as personal work stations, that were the focus of the prior studies. Similarly, item 9 focused on the completeness of the system in supporting all the various types of sub-analysis required to complete the judgmental task involved, an aspect that was not covered in the prior studies considering that they dealt with systems whose applications were not as problem specific as in this study. Additionally, three items on the Moore & Benbasat instrument and two on the Davis instrument were not used as they were deemed to be not directly relevant to the case of knowledge-based systems.

5.2.3.2 Perceived Usefulness of the Explanations Provided

This construct tested the hypothesized effect of the use of explanations on the degree to which users perceived that using the explanations enhanced their task performance. It was a more focused measure than that of the overall system usefulness discussed in the last section in the sense that it directed the user to specifically consider the explanations component of the overall KBS. Development of the items and scales for this instrument was similar to that of the last section, and as before incorporated the sub-constructs used in the Moore & Benbasat and Davis instruments.
Table 5.4 presents the nine items that were developed. The first seven items and the last item, while

1. Using the explanations provided by FINALYZER-XS enabled me to accomplish the financial analysis task more quickly.

2. Using the explanations provided by FINALYZER-XS improved the quality of the analysis I performed.

3. Using the explanations provided by FINALYZER-XS made the financial analysis task easier to do.

4. Using the explanations provided by FINALYZER-XS enhanced my effectiveness in completing the financial analysis task.

5. Using the explanations provided by FINALYZER-XS gave me more control over the financial analysis task.

6. Using the explanations provided by FINALYZER-XS increased my productivity.

7. The explanations provided by FINALYZER-XS had a significant impact on my judgements.

8. My understanding of financial analysis has been enhanced by the use of the explanations provided by FINALYZER-XS.

9. Overall, I found the explanations provided by FINALYZER-XS useful in analyzing the financial statements.

Table 5.4: Items Used for Measuring Usefulness of the Explanations Provided

being worded slightly differently, are similar in content to their equivalents presented in Table 5.3 and as discussed earlier. Item 8 was added to take into consideration of the fact that improving the understanding of users about the task domain was a fundamental goal of providing explanations and would possibly have an impact on the perceptions of explanation usefulness. Additionally, the item that related to the completeness of the system in terms of the various sub-analysis performed was not included.
Prior to the use of both the two instruments in the data analysis, various validity and reliability tests were performed. These tests suggest that they had a high degree of validity and reliability. They are reported in detail in Chapter 6 together with the results of the study.

5.3 Research Design

All three of Campbell and Stanley's [1963] *true experimental designs* were considered for use in conceptualizing the appropriate experimental design. The pretest-posttest control group design would have involved using a repeated measures design with subjects in all treatment groups initially performing the experimental task in the NONE explanation provision condition, i.e., with no KBS explanations being available to them. These would have yielded a pretest score. The subjects would then repeat the experimental task, this time with the explanations pertaining to their respective treatment groups being provided to them, yielding a posttest score. While this design would have minimized the number of treatment groups used by eliminating the need for the NONE condition or no explanations provided control group, it had the disadvantage of possibly causing the subjects to react differently to the treatments because the pretest would "prime" their responses during the posttest. To guard against this danger of a reactive pretest and the strong priming and presensitization effects that are to be expected, it was decided that this design option would not be appropriate. For these same reasons, and for the fact that the extra gains from using the Solomon four-group design would not have been worth the doubling of effort that would have been required, especially from the practical viewpoint of meeting sample size requirements, this second design option was also not deemed feasible.
Instead, after careful consideration of the research hypotheses of Chapter 3 and the operationalization and measurement of the independent and dependent variables discussed in Section 5.2 and 5.3, a posttest only control group 4 X 2 factorial design was selected as shown in Tables 5.5 and 5.6. The eight treatment cells obtained by crossing the four levels of explanation provision strategy with the two levels of user expertise resulted in a primarily between subjects design with a separate treatment group for each cell. With this design, it was possible to evaluate all the research hypotheses in a between subjects manner, with the exception of those relating to the types of explanations (Why, How and Strategic) used. These were evaluated within subjects. It is also important to consider the role of the control groups, i.e., groups 1 and 5 whose subjects were not provided with any explanations at all. These groups served as control groups only for the investigation of the impact of explanation use. For the investigation of the determinants of the use of explanations they were not of use and were eliminated. Having no explanations provided to these subjects ensured that their explanation scores were by default zero. While this had an unbalancing influence on the factorial design, it was felt that it still was the best option as compared to the alternatives.

Table 5.5: Research Design

<table>
<thead>
<tr>
<th></th>
<th>No Explanations</th>
<th>Feedforward Only</th>
<th>Feedback Only</th>
<th>Both Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novices</td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 3</td>
<td>Group 4</td>
</tr>
<tr>
<td>Experts</td>
<td>Group 5</td>
<td>Group 6</td>
<td>Group 7</td>
<td>Group 8</td>
</tr>
</tbody>
</table>
Note in Table 5.6, that subjects were randomly assigned to the various treatment groups. This was performed in a two step procedure to take into account the operationalization of the user expertise construct as discussed in Section 5.1.2. Subjects were initially deliberately assigned or blocked into either an expert or a novice pool depending on their qualifications and experience. Next, subjects in the novice pool were randomly assigned to one of the four novice groups, while those in the expert pool were assigned randomly to the one of the four expert groups. Prior to the subjects performing the experimental task using a variation of the experimental system pertaining to their treatment condition (X), all subjects completed two tutorials. This was to ensure that all subjects reached an equivalent stable state of learning about the use of the experimental system and to guard against novelty effects. These are discussed in detail in the next section as part of the experimental procedures.

| R_{(novice)} | X_{group 1: no explanations} | O_1 |
| R_{(novice)} | X_{group 2: feedforward explanations} | O_2 |
| R_{(novice)} | X_{group 3: feedback explanations} | O_3 |
| R_{(novice)} | X_{group 4: both explanations} | O_4 |
| R_{(expert)} | X_{group 5: no explanations} | O_5 |
| R_{(expert)} | X_{group 6: feedforward explanations} | O_6 |
| R_{(expert)} | X_{group 7: feedback explanations} | O_7 |
| R_{(expert)} | X_{group 8: both explanations} | O_8 |

Table 5.6: Experimental Format
5.4 Experimental Procedures and Subjects

This section will present details of the subject population and their recruitment, as well as the experimental procedure followed. Discussion of the financial analysis domain, the experimental task used, and the development of the experimental system is not included as it is described in Chapter 4.

5.4.1 Sample Size and the Recruitment of Subjects

Statistical power analysis [see Chapter 8 of Cohen, 1988], estimates of the variance expected that were obtained from pilot subjects who completed the experimental task initially, and pragmatic considerations relating to the difficulty of recruiting a large number of experts in financial analysis, were taken into consideration in deciding on the sample size that was required. As well, to facilitate statistical analysis by minimizing the complexity of the research design, a decision was made to have balanced group sizes for the eight treatment groups. Balancing these considerations, a target

<table>
<thead>
<tr>
<th>Significance Level:</th>
<th>0.01</th>
<th>0.05</th>
<th>0.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detecting a Medium Main Effect: ((f=0.25))</td>
<td>11%</td>
<td>29%</td>
<td>42%</td>
</tr>
<tr>
<td>Detecting a Large Main Effect: ((f=0.4))</td>
<td>45%</td>
<td>70%</td>
<td>80%</td>
</tr>
</tbody>
</table>

of 80 subjects was set, with ten subjects to each treatment group. Considering the largely between subjects design, an assessment of this sample size using power analysis [Cohen, 1988, pp. 284] yielded the results presented in Table 5.7. Based on these, it was felt that a power level of 70\% for detecting a large main effect for \(\alpha = 0.05\) would be adequate. Additionally, it was also resolved
that, in the analysis of the data, alpha would be controlled at both the commonly accepted 0.05 level as well as the less rigorous 0.10 level.

Recruitment of novice subjects was handled independently from the recruitment of expert subjects. Initially, two distinct information packages were developed for the two groups of subjects. These are included in Appendix 1 that presents all the material used for recruiting subjects. These packages comprised an information sheet detailing the study and specifying the criteria for participation and the tasks involved, a consent form, and a background information questionnaire to be filled out by prospective subjects. Also included were instructions as to how the consent form and questionnaire could be returned to the investigators. Participation was completely voluntary.

A total of 896 copies of the information package for novices were distributed to prospective subjects. Of these 340 were distributed to undergraduate students and 46 to graduate students in accounting or finance. Distribution was generally done at the start of class and subsequent to the researcher making a short five minute presentation of the objectives of the study and the benefits to students of participation. As well, the cooperation of the local chapters of the Canadian Certified General Accountants Association and the Canadian Institute for Chartered Accountants was also obtained in distributing the packages to their students. A total of 250 copies of the package were distributed by the former organization and 260 copies by the latter. Out of this total of 896 distributed, 43 positive responses were received and 41 novices participated.

Information packages for expert subjects were distributed in two ways. Members of the Vancouver and Edmonton chapters of both the Society of Financial Analysts and the Financial
Executives Institute were sent a copy of the package as part of their respective organizations' regular mail outs. A total of 320 were mailed out to members of the Society of Financial Analysts and another 145 to members of the Financial Executives Institute. Additionally, a further 74 were distributed to prospective subjects in financial and lending institutions who were contacted directly by letter or phone. Generally, this involved the researchers making contact with and obtaining the cooperation of one individual in each institution. This individual would then distribute copies of the package to prospective subjects who were his peers or subordinates. Of a total of 539 distributed, 46 were returned and 43 were eventually scheduled.

5.4.2 Experimental Procedures

Figure 5.3 presents a summary of the experimental procedure followed. Sessions were scheduled by phone and were conducted individually by a laboratory assistant who was present throughout the whole session. Considering that data was collected at two locations, the two laboratory assistants were furnished with the same set of detailed written instructions as to the conduct of each step of the data collection process. A copy of these instructions are attached as Appendix 3. The researcher also trained both the assistants in the procedure to be followed and observed their performance at some of the sessions. To avoid mix-ups and the loss of experimental material, the experimental task material was sequentially pre-numbered and different coloured paper was used to signify the various treatment groups. Copies of these experimental task packages are attached as Appendix 2, at the end of the dissertation.

Before the arrival of a participant, the laboratory assistant reviewed the Background Information Question sent in by each of the participants and noted information about the
FIGURE 5.3: Summary of Experimental Procedure
participant’s familiarity with business computing, use of the mouse input device, and expert systems in general. This helped the assistant to anticipate any problems that might occur during the session. On arrival, participants read a one page General Information Sheet that told them that the objectives of the study were to 1) evaluate the use of a financial analysis expert system to complete a loan analysis case, and 2) evaluate the judgments made with the assistance of such a system. It was not revealed that explanation use was a focus of the research. The laboratory assistant also reviewed the contents of this information sheet with the participants to ensure that they understood it correctly. Particular attention was drawn to the overview of the complete session presented in the description to ensure that subjects knew what to expect at any stage of the session. It was also emphasized that time was not a factor in the study and that they should take as long as they wished at any stage.

Participants were then told to sit facing a 33 megahertz DOS-type personal computer with a colour screen. They were then given a step-by-step tutorial that familiarised them with the use of the mouse input device. All the screens of this tutorial are shown in Appendix 4. The application chosen for the tutorial was the provision of information relating to the climate, the universities, and the sports teams of Western Canadian cities. It was a simple application providing information that should generally be familiar to the subjects. The objective was to minimize the stress and anxiety of those participants who were unfamiliar with the hardware and software while they learned the use of the mouse device in relation to the push-buttons, radio-buttons, and the multiple windows concept [Borland International, 1991] that the experimental system used. At the same time, it had to keep the interest of those participants who were already familiar with such interfaces, as they went through the motions of completing the tutorial. At the end of the tutorial, all subjects were
allowed as much time as they wished to step through the tutorial system again until they felt comfortable and confident in the use of the system.

Next, participants were given another information sheet entitled "A Short Note on Expert Systems" (see Appendix 2). This sheet defined in simple terms what expert systems were, briefly explained how they were developed, and using the analogy of a human expert in medical diagnosis illustrated what they could expect from such a system in terms of input information and conclusions. As well, participants in the treatment groups that were to receive explanations were told that expert systems could also provided explanations and the three kinds of explanations they were to receive were defined precisely for them. For participants who were to receive only feedforward explanations these definitions were couched in input information terms, while those who were to receive only feedback explanations had their definitions put in terms of output information. For participants receiving both feedforward and feedback explanations the definitions were combined to be inclusive using the co-ordinate conjunction "or". As well, subjects were told that they could keep these definitions in front of them throughout the time they used the KBS. As well, the laboratory assistants were instructed to ask the participants if they were clearly understood the three types of explanations. They were also told to use the analogy of a naive child asking questions about the world, such as "Why is the sky blue?", "How did the sky become blue?", and "What role does the blue sky play in the greater scheme of things", to clarify and distinguish between these three explanations. However, few participants had trouble understanding them.

At the next step, participants were required to use the CREDIT-ADVISOR tutorial expert system simulation for evaluating consumer credit applications. As before, they were given a step-by-
step tutorial to guide them and all participants were required to use perform the tutorial. They were also told that the FINALYZER-XS KBS they would be using later had an interface similar to this system. As was the case for the FINALYZER-XS KBS, it was not revealed to them that the CREDIT-ADVISOR system was a simulation. As described in Chapter 4, conscious effort was put into ensuring that this tutorial system had a high level of expertise and appeared as functional as the FINALYZER-XS KBS. This was critical to minimize the novelty effect of being overwhelmed or "seduced" by the quality of the expertise of the KBS at the later stage. As well, subjects were told to take as much time as they wished to understand the CREDIT-ADVISOR system by stepping through it more times. This combined with the fact that no problem-solving case was imposed upon the participants at this stage ensured that subjects who could be considered to be the "tinkerous-types" had ample opportunity to satisfy their curiosity before they used the experimental session. This reduced another possible novelty effect and ensured that subjects reached "steady-state" prior to the main experimental session. The laboratory assistants also made sure that the participants who were to receive explanations did use and familiarized themselves with all the three kinds of explanations that were available to them. As well, participants were also told to relate the explanation definitions placed in front of them to examples that were provided by the CREDIT-ADVISOR system. This was necessary to ensure that they adequately understood what to expect for each type of explanation. Just as it was to be the case with the main experimental system, the explanations that CREDIT-ADVISOR provided were dependent on the treatment group to which participants belonged. A copy of the screens of CREDIT-ADVISOR are presented in Appendix 5.

The participants were then asked to move to another desk that was placed away from the computer. Here, they were given a copy of the Canacom Corporation Loan Analysis Case together
with a set of Judgment Recording Sheets. They were told to familiarize themselves with the case and with the judgments that had to be made and to ask any questions that they wished to have clarified. Although all the ratios and other computations were given to them in the form of tables, they were also provided with a financial calculator and paper to write on. They were then told to analyze the case without the use of the KBS and complete the eight judgments. Initially, it was felt that there was no need to have the participants make these eight judgments at this stage. However, pilot testing revealed that doing so got them more involved and focused in their analysis, as well as better familiarized them with the task and the judgments. As well, it better replicated the real-life situation (external validity) of users using an expert system for financial analysis. Most users of such systems would manually analyze and form some judgments about a company before they consulted an expert about it. Thus, all participants were required to complete the judgments manually prior to them consulting the FINALYZER-XS knowledge-based system. While these judgments were not used in the main data analysis, they served as a manipulation check in relation to how the KBS affected their judgments. As before, participants were given as much time as they wished to complete this stage.

While participants were manually analyzing the Canacom case, the laboratory assistants were instructed to load on to the computer the relevant version of the experimental system with the name of the log file specified correctly. On handing in their completed Judgment Recording Sheets, participants were given a new set of these sheets and reseated in front of the computer screen. They were then told to use the experimental system to help them re-analyze the case and make the eight judgments again. They were allowed as much time as they wished and the computer recorded every keystroke that they made. The laboratory assistants were instructed to sit unobtrusively at the back
of the room during this stage. However, they were required to keep track of the seven sub-analyses of FINALYZER-XS that the participants used. They had to ensure that the participants used all seven of them. However, the order in which they were used was completely dependent on the subject's preferences. During this entire stage, no mention was made to the participants about the explanations provided by the system and they were free to use as many or as few of them as they wished. When participants had finished using the system and were at the final "OVERALL SUMMARY" screen (see Appendix 6 for copies of all the screens that comprised the KBS), they were reminded to complete the eight judgments again. The completed Judgment Recording Sheets were then collected and verified as to their completeness.

A post-study questionnaire comprising the items measuring user perceptions of both the usefulness of the system and the explanations used was then administered. Also included were measures of other secondary constructs that served as manipulation checks, e.g., the ease-of-use of the system and motivation to use the explanations. Their primary purpose was to determine if participants had trouble using the system or were properly motivated. As well, open-ended questions were included that asked for subject's subjective opinions of the major strengths and weaknesses of the system they used, how they would improve the system, and what changes they would like to see in the way the system provided explanations. A copy of this post-study questionnaire is included in the experimental task material of Appendix 2.

At the end, participants were thanked for their participation and debriefed by being presented with a one-page debriefing protocol (see Appendix 2) which was reviewed with them by the laboratory assistant. This revealed to them the true objectives of the study and the nature of the KBS
they used. As well, the reasons as to why this information was not revealed to them earlier were also provided. Novice subjects were also paid an honorarium as is discussed in the next section. The total elapsed time between the arrival of a participant and the completion of the debriefing ranged typically between 1.5 to 2.5 hours, with the average being slightly less than two hours.

5.4.3 Performance Incentives and Payment to Subjects

Monetary incentives have been shown to improve the accuracy of decision making, particularly on realistic judgment tasks that are reasonably complex [Wright and Aboul-Ezz, 1988]. Participants in each treatment group were given the same incentive for overall judgment performance. Specifically, they were informed that a $50 prize was to be awarded to the top twenty percent of participants, participating under similar circumstances, who obtained the most accurate scores. It was emphasized that there was a one out of five chance of winning a prize. They were informed of this incentive in the General Information Sheet they read on arriving for the experimental session. It was also emphasized to them that the time taken for completing the task was not a criteria for the awarding of a prize. Considering that the primary dependent variable of judgmental accuracy is a measure of decision effectiveness and not efficiency, this was to help ensure that participants were not put into situations where they are forced to make tradeoffs between viewing explanations and completing the task quickly.

Novice participants were paid an honorarium of $12 for their participation. This amount was not contingent on the amount of time that they spend on the experimental task or on the quality of their performance. The motivation for this payment was solely to encourage them to participate in the experiment by partially reimbursing them for their time and the costs they incurred in
participating. Expert participants were not offered this payment as it was felt that this amount was not significant enough to encourage the participation of the experts or even as a reimbursement for their time. Considering that the average amount of time that participants took to complete all the various steps of the experimental session was approximately 2 hours, this payment cannot be considered to be adequate reimbursement for the time of either category of the participants.

5.5 Basic Approaches to Data Analysis

The primary methods of data analysis used were the three sub-categories of the Multivariate General Linear Hypothesis (MGLH) statistical model: regression, analysis of variance, and multivariate analysis. It was of course imperative that the data met with the assumptions underlying this model. Table 5.8 presents a summary of the basic statistical models that were run and whose results are presented in Chapter 6. As specified in Model 1 the determinants of the use of explanations were analyzed using ANOVA analysis. Both of the two independent variables of explanation provision strategy and user expertise were evaluated between subjects, while the types of explanations were analyzed within subjects. As was discussed earlier the user expertise variable had two levels, the explanation provision strategy variable had three levels (the none group had no usage scores), and the types of explanation variable had three levels. Model 2 tested the hypotheses relating to the relationship between level of user agreement and the use of explanations. The unit of analysis for this model was not each individual subject as for Model 1, rather it was each conclusion presented by the system for which the user had to specify his or her level of agreement. There were 25 such agreements provided by each participant. As well, the dependent variable for this model was the number of explanations used that were related to each conclusion that was rated for agreement. Hypotheses relating to the impact of the use of explanations on the accuracy of
Model 1: \[ \text{EXPLANATION USE} = B_0 + B_1(\text{EPS}) + B_2(\text{UE}) + B_3(\text{TYPES}) + B_4(\text{EPS*UE}) + B_5(\text{EPS*TYPES}) + B_6(\text{UE*TYPES}) + B_7(\text{EPS*UE*TYPES}) + e \]

Model 2: \[ \text{EXPLANATION USE} = B_0 + B_1(\text{AGREEMENT}) + B_2(\text{UE}) + B_3(\text{AGREEMENT*UE}) + e \]

Model 3: \[ \text{ACCURACY} = B_0 + B_1(\text{USAGE-FF}) + B_2(\text{USAGE-FB}) + e \]

Model 4: \[ \text{USEFULNESS} = B_0 + B_1(\text{USAGE-FF}) + B_2(\text{USAGE-FB}) + e \]

Model 5: \[ \text{ACCURACY} = B_0 + B_1(\text{TYPES USED}) + e \]

Model 6: \[ \text{USEFULNESS} = B_0 + B_1(\text{TYPES USED}) + e \]

Legend:  
\[ B_0 = \text{Alpha} \]  
\[ B_n = \text{Beta Weights} \]  
\[ e = \text{Error Term} \]  
\[ \text{EPS} = \text{Levels of Explanation Provision Strategies} \]  
\[ \text{UE} = \text{Levels of the User Expertise Construct} \]  
\[ \text{TYPES} = \text{Three Types of Explanations Provided} \]  
\[ \text{AGREEMENT} = \text{Level of User Agreement with a Conclusion} \]  
\[ \text{USAGE} = \text{Proportions of Feedforward & Feedback Explanations Used} \]  
\[ \text{TYPES USED} = \text{Proportions of Use of Each Explanation Type} \]

Table 5.8: Basic Statistical Models

Judgmental decision making and user perceptions of usefulness were evaluated using multiple regression analysis (Models 3 through 6). This was because the independent variables of explanation usage (USAGE) and types of explanations used (TYPES USED) were both non-categorical measures and there were multiple measures for both the accuracy of judgments and user perceptions of usefulness. However, when user expertise was included as part of these analysis, ANOVA models were used.

Structural equation modelling [Bagozzi, 1977] was also performed to test the complete research model as presented in Figure 5.1. The objective was to supplement the main statistical
analysis while minimizing the overall measurement error involved. It represents a way of combining the analysis of the determinants of explanation use with the analysis of the impact of explanation use into one single model. A structural equation model, similar to that presented in Figure 5.4, and which represents the causal modelling variation of the research model of Figure 5.1, was fitted using the Partial Least Squares (PLS) method of structural equation modelling [Wold, 1979]. Similar to LISREL [Joreskog and Sorbom, 1984], the PLS method can be characterized as being a "second generation" multivariate analysis technique [Fornell, 1982].

PLS was selected for use over LISREL for a few reasons. First, it better accommodates the small sample size of this research than LISREL. Second, the model to be fitted includes both
formative and reflective indicators. For example, the use of explanations is "formed" by the separate measures for the use of the three different types of explanations, and the accuracy of judgments latent variable is "reflected" in the eight accuracy measures that were taken. Third, both the two independent variables of user expertise and explanation provision strategy were operationalized as categorical, non-interval measures. These cannot be handled easily by LISREL. Fourth, unlike LISREL the estimates of PLS do not require adherence to any distributional assumptions. Fifth, considering that the study of the determinants and consequences of the use of KBS explanations is at the infancy stage of theory formation, PLS is more appropriate. Unlike LISREL, it is just as suitable for exploratory analysis as for theory validation.
The model in Figure 5.4 only included the paths that were directly being hypothesized in this study. As well, there was the consideration that the various treatment groups received different sets of explanations and therefore had varying numbers of usage scores. For example, in the cases where neither one or both of the feedforward and feedback explanations were provided, some usage scores were not captured. This meant that combining the data of all the groups into one set for the use of explanations latent variable was not completely consistent. To overcome these concerns, a second model, that was similar to that presented in Figure 5.5, was fitted. The Explanation Provision Strategy latent variable of Figure 5.4 was dropped and additional paths from user expertise to the accuracy of judgments and perceptions of usefulness were added. This second model was run separately for each of the eight groups and their results were compared. Chapter 6 and Appendix 8 will discuss in detail the specific models that were fitted.

5.6 Summary of the Chapter

This chapter presented the details of the experiment that was conducted to test the hypotheses that were developed in Chapter 3. Besides describing the operationalization of the independent and dependent variables, it presented the research design, procedures used for data collection, and the basic statistical methods used for analyzing the data. The next chapter will present the statistical findings of the study.
6.0 Introduction

This chapter reports the results of the laboratory experiment designed to test the hypotheses discussed in Chapter 3. Each hypothesis is assessed in the context of the conceptual model developed in Chapter 3, and the knowledge-based system (KBS) and task domain described in Chapter 4. Four kinds of quantitative data collected in the experiment were used as dependent variables: 1) measures of the use of explanations obtained from computer logs, 2) measures of the accuracy of judgmental decision-making computed from the judgments made by subjects after using the KBS, 3) measures of user perceptions of "system usefulness" and "explanation usefulness" captured in the post-experimental questionnaire, and 4) measures of user agreement with the conclusions presented by the KBS, obtained from the computer logs of the experimental session.

The use of this data for the assessment of the research hypotheses is organized as follows. The next section details the manner in which the assumptions underlying the statistical model used were verified. Section 6.2 describes how the reliability and validity of the data was assessed for both the independent and dependent variables. Section 6.3 presents the results of the tests relating to the factors influencing the use of KBS explanations. Section 6.4 focuses on the results pertaining to the relationship between the level of user agreement and the use of explanations. Section 6.5 offers the results of the tests relating to the impact of the use of explanations on the accuracy of judgmental decision-making and user perceptions of usefulness. The last section reports the results of the secondary data analysis performed, including the use of structural equation modelling and
other tests that served as manipulation checks.

6.1 Evaluation of the Assumptions Underlying the Statistical Tests

The analysis of variance (ANOVA) procedure of the Multivariate General Linear Hypothesis statistical model [SYSTAT, 1990] was used to analyze the experimental data. Three conditions must be satisfied before ANOVA can be used to test the equality of several population means: 1) each population must be normally distributed; 2) the variances of all populations must be equal; and 3) all sample observations must be independent [Mills, 1977]. The first two of these basic assumptions of the ANOVA model were formally tested in relation to each of the dependent variables. The third assumption of independent treatment effects was satisfied through the research design of the study, by operationalizing both of the independent variables, i.e., user expertise and explanation provision strategy, as between-subjects variables. By having a separate treatment group for each combination of the levels of these independent variables (see the research design presented in Section 5.3), and exposing each subject to only one of the treatments ensured that the requirements of this assumption were met. As well, the independence of sample observations was further assured by requiring all subjects to provide an agreement that they would refrain from discussing, any aspect of their participation in the study, with other participants (see the Consent Form that is included in Appendix 1).

The assumption of multivariate distributional normality was tested prior to testing for the homogeneity of variances assumption. This was done so that variables not conforming to the normality assumption could be appropriately transformed prior to the assessment for homogeneity of variances. Distributional normality was assessed in multiple ways including: 1) evaluations of the
differences between the means and medians, 2) assessments of the measures for skewness and kurtosis, 3) examinations of the shape of normal density plots, and 4) the use of the Kolmogorov-Smirnov Test [Siegel, 1956] for the shape and location of a sample distribution together with the Lillefors Normal Probability Test [Lillefors, 1967] that utilizes the standard normal distribution [SYSTAT, 1990]. The variables that did not conform to the assumption of multivariate distributional normality were transformed using various transformation algorithms, e.g., the arc-sine, natural logarithm, and Fisher's Z algorithms [SYSTAT, 1990; Box and Cox, 1964]. The homogeneity of variances assumption was assessed for each dependent variable through the use of Bartlett's test for the homogeneity of group variances [Neter, Wasserman and Kutner, 1985].

The results of the Kolmogorov-Smirnov (Lillefors) Test are presented in Table 6.1. Lillefors p-values greater than 0.05 indicate that the distributions approximated the standard normal distribution. Only the two perceptual measures of usefulness conformed to the assumption of distributional normality. All the other dependent variables had to be transformed using tail-stretching transformations in an effort to stabilize their variances [Box and Cox, 1964]. The primary reason for this was that the data for all these variables were measured in the form of proportions [Cohen and Cohen, 1975, p. 254]. The four measures of the use of explanations and the user agreement measure were proportions of the number of explanations selected out of the total number of explanations available. The accuracy measures represented proportions of the differences between subjects' judgment scores and correct scores to the absolute values of the correct scores. Section 5.2 of Chapter 5 discusses in detail the exact computation procedures for these measures.

For each of the variables that required transformation, appropriate transformations were
TABLE 6.1: TESTS OF THE ASSUMPTIONS UNDERLYING THE ANOVA MODEL

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Kolmogorov-Smirnov Test (Lillefors Probability: p-value)</th>
<th>Bartlett Test for the Homogeneity of Group Variances (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Data</td>
<td>Transformation Applied</td>
</tr>
<tr>
<td>Use of Explanations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Why Explanations</td>
<td>0.00</td>
<td>Nat. Log.</td>
</tr>
<tr>
<td>How Explanations</td>
<td>0.00</td>
<td>Nat. Log.</td>
</tr>
<tr>
<td>Strategic Explanations</td>
<td>0.03</td>
<td>Arc-sine</td>
</tr>
<tr>
<td>Total Explanations</td>
<td>0.00</td>
<td>Nat. Log.</td>
</tr>
<tr>
<td>Accuracy of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluative Judgments</td>
<td>0.00</td>
<td>Nat. Log.</td>
</tr>
<tr>
<td>Predictive Judgments</td>
<td>0.01</td>
<td>Arc-sine</td>
</tr>
<tr>
<td>Perceptions of Usefulness:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>0.07</td>
<td>None</td>
</tr>
<tr>
<td>Explanations</td>
<td>0.06</td>
<td>None</td>
</tr>
<tr>
<td>User Agreement</td>
<td>0.00</td>
<td>Nat. Log.</td>
</tr>
</tbody>
</table>

identified and applied based on an evaluation of the shape of the a priori normal density plot. The results of these transformations were then evaluated and the transformation yielding the highest Lillefors probability, an acceptable normal probability plot, and the best measures of kurtosis and skewness was selected. For example, for the use of the Strategic explanations variable, all three of the square root, arc-sine, and natural logarithm transformations yielded acceptable normal density plots and Lillefors probabilities greater than 0.05. However, the arc-sine transformation was
selected amongst them as it yielded the highest Lillefors probability (0.51), an acceptable normal probability plot (see Figure 6.1), and the best measures for skewness and kurtosis.
Figure 6.1 presents normal density plots for the four use of explanations dependent variables prior and subsequent to their transformation using the relevant algorithms. Similarly, Figure 6.2 shows the normal density plots for the accuracy and user agreement dependent variables. The revised Lillefors probabilities after transformation for all these variables are also shown in Table 6.1. Note that the Lillefors probabilities for all the transformed variables are greater than 0.05 and that the shapes of the normal probability plots after transformation resemble the "bell-shaped" curve of the normal distribution. These results suggest that the transformations succeeded in removing the
problems associated with multivariate distributional normality. This is further backed by the fact that ANOVA models with equal cell sizes are robust to minor deviations in normality observed in normal probability plots [Neter, Wasserman and Kutner, 1985, p. 623].

Bartlett's test for the homogeneity of group variances was used to test the second assumption relating to the homogeneity of variances. As can be seen in the last column of Table 6.1, there were no violations of this assumption at the 0.05 level for any of the dependent variables.

For the variables that required transformation, all subsequent statistical tests were performed using the transformed data. The test results for these variables, as reported in the rest of this chapter, are based on their transformed form. However, other secondary data that is reported, such as the tables and plots of the means and standard deviations, are based on the initial, untransformed data that was collected. This was done to facilitate the contextual interpretation and analysis of this data.

6.2 Assessment of the Validity & Reliability of Measurement

Assessment of the reliability and validity of the independent variables is discussed in the next section prior to the assessment of the dependent variables.

6.2.1 Reliability of the Independent Variables

An assessment of the measurement error involved in the operationalization of the independent variables was undertaken. Amongst the independent variables, user expertise was identified as possibly being the weakest construct in this regard. Unlike the "explanation provision
strategy" variable, whose two levels of feedforward and feedback were directly manipulated without measurement error, user expertise was operationalized by categorizing subjects according to two individual characteristics. These were the number of years of experience in financial statement analysis and the possession of professional qualifications. They were used to classify subjects into the expert and novice groups. Both of these individual characteristics were analyzed post-hoc to assess the validity of the categorization used to operationalize user expertise.

**6.2.1.1 Years of experience in financial statement analysis**

An independent samples t-test was performed to test the null hypothesis that the means for

<table>
<thead>
<tr>
<th>Subjects</th>
<th>N</th>
<th>Mean (years of experience)</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novices</td>
<td>40</td>
<td>0.33</td>
<td>0.94</td>
</tr>
<tr>
<td>Experts</td>
<td>40</td>
<td>9.68</td>
<td>4.54</td>
</tr>
</tbody>
</table>

SEPARATE VARIANCES  $T = -12.76$  DF = 42.3  PROB = < 0.001

POOLED VARIANCES   $T = -12.76$  DF = 78  PROB = < 0.001

the number of years of experience were not significantly different between the expert and novice subjects. The 9.35 years difference in the means of the two groups was significant at the 0.05 level. This suggests that categorization based on the years of experience in financial statement analysis was effective in distinguishing between the expert and novice subjects. Only 5 of the 40 novice subjects reported some amount of experience ranging from 1.5 to 3 years. All of the 40 expert subjects had work experience in financial analysis ranging between 4 and 20 years.
6.2.1.2 Professional Qualifications

Only professional qualifications that went beyond the undergraduate degree and that were relevant to the application of financial analysis were considered. These were the Chartered Accountant (CA), Certified Financial Analyst (CFA), and Certified General Accountant (CGA) designations (see Section 5.2). The data was coded as a binary variable with the value 1 denoting the possession of such qualifications and 0 their absence. Considering the nature of this data, a Chi-square test was performed to test the null hypothesis that there was no significant difference between the expert and novice subjects in terms of the possession of professional qualifications. The result of this test is presented above together with a cross-tabulation of the data. There was a significant difference between the expert and novice subjects in terms of their possession of professional qualifications.

In summary, the results of these two tests suggest that the categorization used to operationalize the user expertise construct was successful in differentiating between the expert and
novice levels.

6.2.2 Assessment of the Reliability of the Dependent Variables

The measures relating to the use of explanations were captured reliably without error by recording them directly into the computer logs of the experimental sessions. The two accuracy measures also have a high degree of reliability as they were computed directly from the judgment recording sheets completed by subjects. However, for the constructs relating to user perceptions of the usefulness of the system and of the explanations, a multi-item instrument in the form of the post-study questionnaire was used for measurement. The development of the items comprising this instrument was discussed in Section 5.2.3 of Chapter 5. Prior to the use of these measures of usefulness for the purposes of evaluating the hypotheses, the validity and reliability of the scales comprising this instrument were assessed.

The instrument comprised of three multi-item scales for measuring three perceptual constructs: usefulness of the KBS, usefulness of the explanations provided, and the ease-of-use of the system. Only the first two of these served as dependent variables and were discussed in Chapter 6. The ease-of-use scale was included primarily to serve as a manipulation check for assessing the possible mediating influence of differences in the system’s usability between the various treatment groups. Evaluation of its reliability and construct validity is however also discussed in this section.

The overall reliability of the three scales was assessed using Cronbach’s ALPHA (Cronbach, 1970). As well, the items comprising each scale were evaluated using various item reliability statistics. These included the effect on Cronbach’s ALPHA if an item was deleted, the item standard
deviation score, item-to-total scale correlation, and the correlation of items within each scale (using the Bonferroni probability matrices). The construct validity of the scales was assessed by performing Principal Components Factor Analysis utilizing the Varimax rotation to obtain the eigenvalues, factor loadings, and the percentage of variance explained. The objective was to evaluate the convergence and divergence of items within each scale. All the analysis was performed using the TESTAT module of the SYSTAT statistical package [SYSTAT, 1990].

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>Cronbach's ALPHA</th>
<th>Eigenvalue (Factor analysis)</th>
<th>Percentage of Variance explained by Rotated Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness of the System</td>
<td>10</td>
<td>0.85</td>
<td>4.37</td>
<td>45.8</td>
</tr>
<tr>
<td>Usefulness of the Explanations</td>
<td>9</td>
<td>0.93</td>
<td>5.95</td>
<td>66.1</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>5</td>
<td>0.76</td>
<td>2.65</td>
<td>53.0</td>
</tr>
</tbody>
</table>

Table 6.2 presents the Cronbach's ALPHA, eigenvalues, and the percentage of variance explained for each of the three scales. The values of ALPHA for the three scales are all within or above the 0.60 to 0.80 range, which Nunnally [1967, p. 226] argues is a sufficient reliability level for "basic research." While this assured that the scales were sufficiently reliable, the results of the factor analysis were used to assess construct validity. For each of the three scales, the items comprising the scale were factor analyzed to assess the number of factors that emerged.
In the case of the usefulness of the system construct, the four largest eigenvalues that emerged were as follows: 4.37, 1.16, 0.92, and 0.75. Only the first eigenvalue was significantly greater than 1.0 and a scree plot of all the eigenvalues revealed a break after the first factor. This indicated that a single factor solution was most likely. While this first factor alone accounted for 45.8% of the variance captured, the acceptance of a second factor (eigenvalue = 1.16) would have increased the percentage of variance explained by another 11.6%. Assessment of the "usefulness of the explanations" construct yielded only one eigenvalue that was greater than 1.0. A scree plot of all the eigenvalues confirmed again that a single factor was most appropriate. This first factor with an eigenvalue of 5.95 explained 66.1% of the total variance. This suggests a significantly high level of construct validity. In the case of the third scale that measured the ease-of-use construct, the results were generally similar. The four largest eigenvalues that were obtained were: 2.65, 0.86, 0.67, 0.43, and the one factor solution that resulted explained 53% of the total variance captured. Further confirmatory factor analysis was performed by conducting Principal Component analysis using the VARIMAX rotation on all 24 of the items that measured the three constructs. All three of the expected factors emerged with a reasonable degree of clarity accounting for 61% of the total variance in the data set. A scree plot revealed a clear break after the first three eigenvalues which were all significantly greater than the 1.0 cut-off: 10.04, 2.93, and 1.72.

Examination of the rotated factor loadings was performed jointly with the evaluation of the item reliability statistics for each of the three scales. The objective was to isolate items that reduced either the reliability or the construct validity of the scales. It was felt that the elimination of such items could enhance subsequent statistical analysis conducted to test the research hypotheses. Items that did not load strongly on any factor (loadings of less than 0.5) or loaded strongly on more than
one factor reduced the construct validity of the scales. Items that diminished scale reliability included those: 1) whose deletion would increase Cronbach's ALPHA; 2) with low item-to-item and item-to-total correlations; and 3) with low standard deviance scores. Tables 6.3. through 6.5 present the item reliability statistics, as well as the rotated factor loadings, for each of the scales. Note that the item labels used in the first column of these tables correspond to the question numbers of the items included in the post-study questionnaire. A copy of this is included in Appendix 2.

Examination of the deletion effects on ALPHA presented in Table 6.3 reveals that there was only one item (Q23) whose elimination would improve the overall reliability of the scale measuring the usefulness of the system. However, examination of the standard deviation and item-to-scale correlation of this item, provides some justification for its retention. The item-to-total correlation,
while being lowest among all the items in this scale, is substantially greater than the 0.40 cut-off that is generally used [Moore and Benbasat, 1991]. As well, its standard deviation is larger than that of the other items, suggesting that it has the most explanatory power. Considering that the increase in ALPHA from elimination would have been slight (from 0.85 to 0.856), it was therefore decided that the item would not be culled from the scale. None of the items that measured usefulness of the explanations posed any reliability problems (Table 6.4). All the item-to-total correlations were equal to or greater than 0.71 and Cronbach’s ALPHA could not be increased by eliminating any of the items. Similar assessment of the items measuring ease-of-use (Table 6.5) revealed that item Q4 was a possible candidate for elimination. It had the lowest standard deviation and item-to-scale correlation amongst all the items. However, considering that the increase in ALPHA from its deletion would have been marginal, from 0.76 to 0.765, it was decided that the item would be retained.

As can be seen in the last column of Tables 6.3, 6.4, and 6.5 all the items in the three scales loaded strongly on their respective factors, indicating a high level of convergent validity. The lowest factor loading was 0.52 for item Q23 of the usefulness of the system construct. This is acceptable as it is higher than the loading of 0.45 that is generally considered in the literature to be the lower cut-off level [Comrie, 1973]. As well, the majority of the loadings were in excess of 0.63, which Comrie [1973] considers to be the minimal cut-off level for very good loadings. The rotated factor loadings from the confirmatory factor analysis performed using all the 24 items (see Table 6.6) were examined to identify items that reduced divergent validity, i.e., loaded strongly on more than one factor. A three factor solution was specified. This revealed that there were only two such items: item Q15 which measured usefulness of the system and item Q25 which measured usefulness of the
TABLE 6.4:  
ITEM RELIABILITY STATISTICS & FACTOR LOADINGS:  
USEFULNESS OF THE EXPLANATIONS

<table>
<thead>
<tr>
<th>Item Label</th>
<th>Standard Deviation</th>
<th>Item-Total Correlation</th>
<th>Deletion Effect on ALPHA (base = 0.93)</th>
<th>Rotated Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9</td>
<td>1.20</td>
<td>0.85</td>
<td>0.921</td>
<td>0.85</td>
</tr>
<tr>
<td>Q21</td>
<td>1.23</td>
<td>0.71</td>
<td>0.930</td>
<td>0.71</td>
</tr>
<tr>
<td>Q25</td>
<td>1.50</td>
<td>0.75</td>
<td>0.930</td>
<td>0.74</td>
</tr>
<tr>
<td>Q27</td>
<td>1.05</td>
<td>0.85</td>
<td>0.921</td>
<td>0.86</td>
</tr>
<tr>
<td>Q28</td>
<td>1.20</td>
<td>0.90</td>
<td>0.917</td>
<td>0.90</td>
</tr>
<tr>
<td>Q30</td>
<td>1.28</td>
<td>0.82</td>
<td>0.922</td>
<td>0.82</td>
</tr>
<tr>
<td>Q32</td>
<td>1.32</td>
<td>0.74</td>
<td>0.929</td>
<td>0.74</td>
</tr>
<tr>
<td>Q33</td>
<td>1.16</td>
<td>0.81</td>
<td>0.923</td>
<td>0.82</td>
</tr>
<tr>
<td>Q38</td>
<td>1.44</td>
<td>0.85</td>
<td>0.920</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Besides loading strongly on their respective constructs, both of these items also loaded heavily on the ease-of-use construct with loadings of 0.63 and 0.60 respectively. Examination of the contents of both items reveals that they measure a common dimension of usefulness that relates to the improvement in the efficiency, or quickness, with which the underlying problem-solving task can be performed. For example, a system or system feature that enhances the efficiency of the problem-solving process will be perceived as being useful. Item Q15 comprises the statement "Using the explanations provided by FINALYZER-XS allows me to accomplish the financial analysis task more quickly", while Q25 states that "Using FINALYZER-XS allows me to accomplish the financial analysis task more quickly". While prior studies [Davis, 1986; Moore and Benbasat, 1991] have considered this dimension to be solely a sub-construct of usefulness, subjects in this study clearly viewed it as being a measure of ease-of-use as well. Considering that these two items did not clearly discriminate between the usefulness and ease-of-use constructs, they were therefore culled from their
### TABLE 6.5:
**ITEM RELIABILITY STATISTICS & FACTOR LOADINGS: EASE-OF-USE**

<table>
<thead>
<tr>
<th>Item Label</th>
<th>Standard Deviation</th>
<th>Item-Total Correlation</th>
<th>Deletion Effect on ALPHA (base = 0.76)</th>
<th>Rotated Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4</td>
<td>0.61</td>
<td>0.54</td>
<td>0.765</td>
<td>0.58</td>
</tr>
<tr>
<td>Q7</td>
<td>1.03</td>
<td>0.80</td>
<td>0.681</td>
<td>0.78</td>
</tr>
<tr>
<td>Q10</td>
<td>1.26</td>
<td>0.79</td>
<td>0.727</td>
<td>0.73</td>
</tr>
<tr>
<td>Q29</td>
<td>0.77</td>
<td>0.76</td>
<td>0.693</td>
<td>0.81</td>
</tr>
<tr>
<td>Q34</td>
<td>0.87</td>
<td>0.71</td>
<td>0.718</td>
<td>0.73</td>
</tr>
</tbody>
</table>

In summary, the three scales comprising the instrument were found to be sound from the perspective of reliability of measurement. As well, in relation to the assessment of construct validity, there was substantial evidence relating to the convergent and divergent validity of the items comprising the scales. Aspects of the content validity were discussed earlier in Section 5.2.3 of Chapter 5 in relation to the development of the scales. Considering that the items were assembled based on reliable and valid instruments that arose out of past studies that focused specifically on the theoretical dimensions of the usefulness and ease-of-use constructs [Davis, 1986; Moore and Benbasat, 1991], it can be argued that a reasonable degree of content validity is assured.

### 6.3 Results Pertaining to the Factors Influencing the Use of Explanations

The primary statistical model used to investigate the hypotheses relating to the use of explanations is presented in Figure 6.3. It is a mixed ANOVA model with "explanation provision
strategy" and "user expertise" being between-subject factors and the "types of explanations" being a within-subjects factor. The model was run using the MGLH module of SYSTAT [SYSTAT, 1990] with a sample size of 60 subjects. The 20 subjects who had no scores for the use of feedforward and feedback explanations because they were not provided with any explanations were not included.

There were three levels of explanation provision strategy: (a) only feedforward explanations; (b) only feedback explanations; and (c) both feedforward and feedback explanations. User expertise was measured at two levels: experts and novices. The three types of explanations provided were the Why, How, and Strategic explanations. Table 6.7 presents the results of the ANOVA model, while
**Model:**  
$$EXPLANATION \ USE = B_1(\text{EPS}) + B_2(\text{UE}) + B_3(\text{TYPES}) + B_4(\text{EPS*UE}) + B_5(\text{EPS*TYPES}) + B_6(\text{UE*TYPES}) + B_7(\text{EPS*UE*TYPES}) + e$$

Legend:  
$B_\_ = \text{Beta Weights}; e = \text{Error Term}$

EXPLANATION USE = Usage Proportions of the Why, How, and Strategic Explanations  
EPS = Three Types of Explanation Provision Strategies: Feedforward Only, Feedback Only, and Both Feedforward and Feedback  
UE = Expert and Novice Levels of User Expertise  
TYPES = Why, How and Strategic Explanations Provided

**Hypotheses : Main Effects**

**H1:** Feedback explanations will be used as much as the feedforward explanations (FB = FF).

**H2:** Novices will use more explanations than experts (NOVICES > EXPERTS).

**H3:** The why explanation will be used the most, and the how explanation will be used more than the strategic explanation (WHY > HOW > STRATEGIC).

**Hypotheses : Interaction Effects**

**H4:** Novices will use more feedforward explanations than feedback explanations, while experts will use more feedback explanations than feedforward explanations.

**H5:** For both feedforward or feedback explanation provision, the why explanation will be used the most, and the how explanation will be used more than the strategic explanation.

**H6a:** Novices will use the why explanation the most, and the how explanation more than the strategic explanation.

**H6b:** Experts will use the how explanation the most, and the strategic explanation more than the why explanation.

**H7a:** For both feedforward or feedback explanation provision, novices will use the why explanation the most, and the how explanation more than the strategic explanation.

**H7b:** For both feedforward or feedback explanation provision, experts will use the how explanation the most, and the strategic explanation more than the why explanation.

**Figure 6.3: Statistical Model and Hypotheses Relating to the Use of Explanations**

The means and standard deviations for the various treatment groups are summarized in Table 6.8. Note that the measures for the use of explanations were proportions of the number of explanations selected to the number of explanations provided. Table 5.2 on page 127 presents the denominators
Table 6.7: ANOVA Results for the Use of Explanations

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>D.F.</th>
<th>F-value</th>
<th>Sigf.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. BETWEEN SUBJECTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>1</td>
<td>0.02</td>
<td>0.88</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>2</td>
<td>13.16</td>
<td>0.00</td>
</tr>
<tr>
<td>UE by EPS Interaction</td>
<td>2</td>
<td>0.16</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>B. WITHIN SUBJECTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of Explanations (TYPES)</td>
<td>2</td>
<td>8.80</td>
<td>0.00</td>
</tr>
<tr>
<td>TYPES by UE Interaction</td>
<td>2</td>
<td>2.68</td>
<td>0.07</td>
</tr>
<tr>
<td>TYPES by EPS Interaction</td>
<td>4</td>
<td>2.39</td>
<td>0.06</td>
</tr>
<tr>
<td>TYPES by UE by EPS Interaction</td>
<td>4</td>
<td>0.05</td>
<td>0.99</td>
</tr>
</tbody>
</table>

used in the computation of these proportions, i.e., the total number of explanations provided for each treatment condition. The results are discussed below in relation to each of the hypotheses (H1 - H7) pertaining to the determinants of the use of explanations.

6.3.1 Hypothesis 1: Feedback and Feedforward Explanation Provision

There is a significant difference in the proportion of feedback and feedforward explanations used ($F = 13.16; p < 0.001$). H1 was rejected. The relevant group means from Table 6.8 are displayed in Figure 6.4. Subjects provided with only feedforward explanations used 7.4% of the available explanations, while subjects provided with only feedback explanations used 28.1%. The total percentage of explanations used by subjects who were provided with both feedforward and feedback explanations was 12.4%. A decomposition of this percentage reveals that subjects who were provided with both used 5.8% of the feedforward explanations and 26.5% of the feedback.
## TABLE 6.8: DETAILED STATISTICS FOR THE USE OF EXPLANATIONS

<table>
<thead>
<tr>
<th>Explanation Provision Strategy</th>
<th>Novices</th>
<th>Experts</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Groups Receiving Only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedforward Explanations (FF)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF Why</td>
<td>.092</td>
<td>.108</td>
<td>.064</td>
</tr>
<tr>
<td>FF How</td>
<td>.053</td>
<td>.064</td>
<td>.132</td>
</tr>
<tr>
<td>FF Strategic</td>
<td>.051</td>
<td>.045</td>
<td>.049</td>
</tr>
<tr>
<td>Total FF</td>
<td>.065</td>
<td>.067</td>
<td>.082</td>
</tr>
<tr>
<td>Groups Receiving Only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback Explanations (FB)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FB Why</td>
<td>.408</td>
<td>.347</td>
<td>.336</td>
</tr>
<tr>
<td>FB How</td>
<td>.272</td>
<td>.225</td>
<td>.36</td>
</tr>
<tr>
<td>FB Strategic</td>
<td>.16</td>
<td>.189</td>
<td>.149</td>
</tr>
<tr>
<td>Total FB</td>
<td>.28</td>
<td>.209</td>
<td>.281</td>
</tr>
<tr>
<td>Groups Receiving Both</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedforward and Feedback</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanations (BOTH)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF Why</td>
<td>.113</td>
<td>.162</td>
<td>.051</td>
</tr>
<tr>
<td>FF How</td>
<td>.062</td>
<td>.064</td>
<td>.051</td>
</tr>
<tr>
<td>FF Strategic</td>
<td>.042</td>
<td>.036</td>
<td>.03</td>
</tr>
<tr>
<td>Total FF</td>
<td>.072</td>
<td>.067</td>
<td>.044</td>
</tr>
<tr>
<td>FB Why</td>
<td>.376</td>
<td>.351</td>
<td>.256</td>
</tr>
<tr>
<td>FB How</td>
<td>.24</td>
<td>.24</td>
<td>.344</td>
</tr>
<tr>
<td>FB Strategic</td>
<td>.228</td>
<td>.19</td>
<td>.14</td>
</tr>
<tr>
<td>Total FB</td>
<td>.283</td>
<td>.206</td>
<td>.247</td>
</tr>
<tr>
<td>FF &amp; FB Why</td>
<td>.199</td>
<td>.201</td>
<td>.117</td>
</tr>
<tr>
<td>FF &amp; FB How</td>
<td>.119</td>
<td>.097</td>
<td>.145</td>
</tr>
<tr>
<td>FF &amp; FB Strategic</td>
<td>.101</td>
<td>.071</td>
<td>.065</td>
</tr>
<tr>
<td>Total FF &amp; FB</td>
<td>.14</td>
<td>.094</td>
<td>.109</td>
</tr>
</tbody>
</table>

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explanations that were provided. Pairwise contrasts between the three treatments using the Bonferroni adjustment matrix yields the following probabilities: Only FF and Only FB - p < 0.01; Only FF and BOTH (FF & FB) - p = 0.03; and Only FB and BOTH (FF & FB) - p = 0.01. These contrasts suggest that there is a significant difference in the proportion of explanations used by subjects in the three treatments. Overall, the use of feedback explanations is approximately four times greater than the use of feedforward explanations.

The measure of explanation use for the BOTH (FF and FB) explanation provision strategy was a weighted average of the proportions of feedforward and feedback explanations used.
Model 2: \[ \text{FEEDFORWARD USE} = B_1(\text{EPS}) + B_2(\text{UE}) + B_3(\text{TYPES}) + B_4(\text{EPS*UE}) + B_5(\text{EPS*TYPES}) + B_6(\text{UE*TYPES}) + B_7(\text{EPS*UE*TYPES}) + e \]

Model 3: \[ \text{FEEDBACK USE} = B_1(\text{EPS}) + B_2(\text{UE}) + B_3(\text{TYPES}) + B_4(\text{EPS*UE}) + B_5(\text{EPS*TYPES}) + B_6(\text{UE*TYPES}) + B_7(\text{EPS*UE*TYPES}) + e \]

Legend: \( B_n = \) Coefficients; \( e = \) Error Term

**FEEDFORWARD USE** = Proportions of the Why, How, and Strategic Explanations Used As Feedforward

**FEEDBACK USE** = Proportions of the Why, How, and Strategic Explanations Used As Feedback

**EPS** = Two Types of Explanation Provision: Provided Alone or Together

**UE** = Expert and Novice Levels of User Expertise

**TYPES** = Why, How and Strategic Explanations Provided

Figure 6.3A: Additional Models Used to Investigate Explanation Provision Strategy

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>D.F.</th>
<th>F-value</th>
<th>Sigf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BETWEEN SUBJECTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>1</td>
<td>0.07</td>
<td>0.79</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>1</td>
<td>0.06</td>
<td>0.80</td>
</tr>
<tr>
<td>UE by EPS Interaction</td>
<td>1</td>
<td>0.09</td>
<td>0.77</td>
</tr>
<tr>
<td>B. WITHIN SUBJECTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of Explanations (TYPES)</td>
<td>2</td>
<td>7.67</td>
<td>0.00</td>
</tr>
<tr>
<td>TYPES by UE Interaction</td>
<td>2</td>
<td>2.31</td>
<td>0.11</td>
</tr>
<tr>
<td>TYPES by EPS Interaction</td>
<td>2</td>
<td>0.41</td>
<td>0.67</td>
</tr>
<tr>
<td>TYPES by UE by EPS Interaction</td>
<td>2</td>
<td>0.13</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Table 6.7A: ANOVA Results for the Use of Feedforward Explanations (Model 2)

Therefore, two additional ANOVA models were run to ascertain if the amount of feedforward or feedback explanations used when each was provided individually was significantly different from...
Table 6.7B: ANOVA Results for the Use of Feedback Explanations (Model 3)

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>D.F.</th>
<th>F-value</th>
<th>Sigf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BETWEEN SUBJECTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>1</td>
<td>0.08</td>
<td>0.79</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>1</td>
<td>0.50</td>
<td>0.49</td>
</tr>
<tr>
<td>UE by EPS Interaction</td>
<td>1</td>
<td>1.04</td>
<td>0.31</td>
</tr>
<tr>
<td>B. WITHIN SUBJECTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types of Explanations (TYPES)</td>
<td>2</td>
<td>2.85</td>
<td>0.06</td>
</tr>
<tr>
<td>TYPES by UE Interaction</td>
<td>2</td>
<td>2.78</td>
<td>0.07</td>
</tr>
<tr>
<td>TYPES by EPS Interaction</td>
<td>2</td>
<td>0.70</td>
<td>0.50</td>
</tr>
<tr>
<td>TYPES by UE by EPS Interaction</td>
<td>2</td>
<td>0.77</td>
<td>0.47</td>
</tr>
</tbody>
</table>

when they were provided together. While these models were generally similar to the main statistical model of Figure 6.3, they used different dependent measures and had only two levels of explanation provision strategy. The first of these models (see Model 2 of Figure 6.3A) had the amounts of feedforward explanations used as the dependent variable and tested if providing the feedforward explanations individually or together with feedback explanations (explanation provision strategy) led to different proportions of feedforward explanations being used. Thus, only the data from the 40 subjects who were provided with feedforward explanations was used for this model. The result of this model (see Table 6.7A) for explanation provision strategy indicate that there is no significant difference ($F = 0.06$, $p = 0.80$) in the amount of feedforward explanations used in the two conditions. Similarly, the second of these models (Model 3 in Figure 6.3A) was run using the data from the 40 subjects who were provided with feedback explanations and had the amounts of feedback explanations used as the dependent variable. Its results for explanation provision strategy
(See Table 6.7B) indicate that there is no significant difference ($F = 0.50$, $p = 0.49$) in the use of feedback explanations, when provided individually or together with feedforward explanations. These results suggest that there is no evidence of a tradeoff between feedforward and feedback explanations when they are provided together.

In summary, the analysis of explanation provision strategy in the three models indicates that 1) feedback explanations are used significantly more than feedforward explanations, and 2) the amounts of feedforward and feedback explanations used are constant, irrespective of whether they are provided individually or together.

6.3.2 Hypothesis 2: User Expertise

Contrary to the model of the determinants of the use of explanations postulated in Chapter 3, there is no significant difference in the total use of explanations by expert and novice subjects ($F = 0.02$, $p = 0.878$). The means and standard deviations are presented in the last row of Table 6.9. This table summarizes the mean and standard deviation statistics for the 60 subjects who received explanations. Overall, novices used 16.2% of the explanations provided to them, while experts used 15.7%.

6.3.3 Hypothesis 3: Types of Explanations

There is a significant difference in the proportions of the How, Why, and Strategic explanations used ($F = 8.80; p < 0.01$). Figure 6.5 presents the overall proportions of use for the three kinds of explanations. It shows that 20.3% of the Why explanations provided, 17.9% of the How explanations provided, and 9.6% of the Strategic explanations provided were used. Multiple
TABLE 6.9: AGGREGATE STATISTICS OF THE USE OF EXPLANATIONS  
(FOR ALL SUBJECTS WHO RECEIVED EXPLANATIONS: N = 60)

<table>
<thead>
<tr>
<th>Explanation Provision Strategy</th>
<th>Novices</th>
<th>Experts</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Feedforward Explanations Used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Why</td>
<td>.103</td>
<td>.134</td>
<td>.058</td>
</tr>
<tr>
<td>How</td>
<td>.058</td>
<td>.062</td>
<td>.092</td>
</tr>
<tr>
<td>Strategic</td>
<td>.046</td>
<td>.04</td>
<td>.04</td>
</tr>
<tr>
<td>Total</td>
<td>.069</td>
<td>.065</td>
<td>.063</td>
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<tr>
<td>Feedback Explanations Used</td>
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<tr>
<td>Why</td>
<td>.394</td>
<td>.344</td>
<td>.296</td>
</tr>
<tr>
<td>How</td>
<td>.256</td>
<td>.227</td>
<td>.352</td>
</tr>
<tr>
<td>Strategic</td>
<td>.194</td>
<td>.187</td>
<td>.144</td>
</tr>
<tr>
<td>Total</td>
<td>.281</td>
<td>.202</td>
<td>.264</td>
</tr>
<tr>
<td>Total Explanations Used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Why</td>
<td>.233</td>
<td>.267</td>
<td>.172</td>
</tr>
<tr>
<td>How</td>
<td>.148</td>
<td>.169</td>
<td>.21</td>
</tr>
<tr>
<td>Strategic</td>
<td>.104</td>
<td>.124</td>
<td>.087</td>
</tr>
<tr>
<td>Total</td>
<td>.162</td>
<td>.161</td>
<td>.157</td>
</tr>
</tbody>
</table>

contrasts were performed to ascertain if these usage proportions supported the results of past studies of the use of KBS explanations, which have found the Why explanation to be the most preferred type of explanation [Ye, 1990]. These contrasts reveal that there was no significant difference between the use of the Why and How explanations (F = 1.08, p = 0.39). However, the differences in usage between 1) the Why and Strategic explanations (F = 3.83, p < 0.01), and 2) the How and Strategic explanations (F = 3.70, p < 0.01), were significant.
6.3.4 Hypothesis 4: Interaction of User Expertise By Explanation Provision

It was hypothesized in Chapter 3 that novices would use a higher proportion of feedforward explanations as compared to feedback explanations. As well, it was hypothesized that experts would use more feedback explanations, as their more developed models of the domain would reduce their need for feedforward explanations. However, no evidence was found for this interaction effect ($F = 0.16, p = 0.85$). Experts and novices displayed a similar behavior in relation to the use of feedback and feedforward explanations. As displayed in Figure 6.6, when only feedforward or only feedback explanations were provided, both experts and novices used a greater proportion of the feedback explanations as compared to the feedforward explanations. When feedforward and
feedback were provided together, the same behavior was observed, i.e., both experts and novices used approximately the same amounts of feedforward and feedback explanations. As well, feedback explanations were used substantially more than feedforward explanations.

6.3.5 Hypothesis 5: Interaction of Explanation Provision and the Types of Explanations

It was hypothesized that there would be no interaction between explanation provision strategy and the types of explanations that are used. However, there was evidence of an interaction effect \( (F = 2.39, p = 0.06) \). Figure 6.7 displays the mean proportions of the Why, How and Strategic explanations that were used for the three levels of explanation provision strategy. It shows
that, with the exception of the case when only feedforward explanations are provided, the Why explanation is consistently used the most and the Strategic explanation the least. Pairwise contrasts were performed to identify the source of the significant interaction effect. While there were no significant differences between the use of the Why, How, and Strategic explanations for the "feedforward only" and "both feedforward and feedback" levels of explanation provision strategy, the Why explanation was used significantly more ($p < 0.01$) than the Strategic explanation for the "feedback only" level.
6.3.6 Hypothesis 6: Interaction of User Expertise and the Types of Explanations

Experts and novices used varying proportions of the Why, How, and Strategic explanations that were provided (F = 2.68, p = 0.07). Figure 6.8 displays the nature of this interaction, while the means and standard deviations were presented in Table 6.9. Novices used a higher proportion of Why explanations (23.3%), followed by How (14.8%) and Strategic (10.4%) explanations. Experts, however, used the How explanation the most (21%), followed by Why (17.2%) and Strategic (11.7%) explanations. Pairwise contrasts of these proportions of use indicate that novices used significantly more Why explanations than Strategic explanations (p = 0.08), while experts used...
significantly more How explanations than the Strategic explanations \( (p = 0.09) \).

### 6.3.7 Hypothesis 7: User Expertise by Explanation Provision by Explanation Types Interaction

The user expertise by explanation provision by types of explanations interaction was not significant \( (F = 0.05, \ p = 0.99) \). The group means for all of the six treatment groups were presented in Table 6.8.

### 6.3.8 Summary of the Results Relating to the Factors Influencing the Use of Explanations

The results indicate that explanation provision strategies and the types of explanations provided influence the use of KBS explanations. Feedback explanations are used significantly more than feedforward explanations. The Why and How explanations are used significantly more than the Strategic explanations. As well, while the level of user expertise was a poor predictor of the use of explanations, novices and experts used different types of explanations. Experts used the How explanations more than the Strategic explanations, while novices used the Why explanations more than the Strategic explanations.

### 6.4 Results Relating the Level of User Agreement to the Use of Explanations

Ye [1990] found that the use of explanations was correlated with the level of user agreement with KBS conclusions. He argues that this is the result of the increased understanding of, and confidence in, a KBS, that is brought about by the use of its explanations. As was discussed in Chapter 3 in relation to the framework of the determinants of explanation use, this result suggests that there would be a reverse effect as well, i.e., the level of initial user agreement with KBS conclusions would influence, to some extent, the amount of explanations that are used. To
investigate the specific nature of this relationship, it was therefore postulated that the lower the level

**Hypotheses**

H8: There is an inverse relationship between the level of user agreement and the number of feedback explanations used.

H9: The relationship between the level of user agreement and the number of feedback explanations used will be the same for experts and novices.

H10: There is no difference in the level of user agreement between experts and novices.

**Statistical Models Used to Test Hypotheses**

Model 1: \( \text{EXPLANATION USE} = B_1(\text{AGREEMENT}) + B_2(\text{UE}) + B_3(\text{AGREEMENT*UE}) + e \)

Model 2: \( \text{AGREEMENT} = B_1(\text{UE}) + B_2(\text{EPS}) + B_3(\text{UE*EPS}) + e \)

Legend:  
- \( B_n \) = Coefficients  
- \( e \) = Error Term  
- UE = Expert and Novice Levels of User Expertise  
- AGREEMENT = Level of User Agreement with a KBS Conclusion  
- EXPLANATION USE = Number of Explanations Used for Each KBS Conclusion  
- EPS = Four Levels of Explanation Provision Strategy

Table 6.10: Hypotheses and Statistical Models Relating to User Agreement

of initial user agreement with a KBS’s conclusions the greater will be the number of feedback explanations that are used, and vice versa (see hypothesis H8 of Table 6.10).

Ye also found that experts were more likely to agree with KBS conclusions than novices. As was discussed in Chapter 3, differences in the level of domain expertise can result in different levels of agreement with a KBS’s conclusions. This suggests that the level of user agreement with a KBS could possibly have a moderating influence on the relationship between user expertise and the use of explanations. Hypotheses H9 and H10, which are stated in null form, were used to test the nature of this potential moderating influence. Hypothesis H10 specifically tested the possibility
of an interaction effect between the level of user agreement and user expertise in influencing the use of explanations. Hypothesis H10 tested for expert-novice differences in the level of user agreement.

Hypotheses H8 and H9 were tested using Model 1 of Table 6.10. The level of user agreement with each conclusion that was presented by the KBS was measured using a single-item, seven-point scale. A level of 1 on the scale denoted the highest level of user agreement and 7 the lowest level of it. This measurement was taken immediately after subjects viewed each conclusion, and before they used any explanations relating to the particular conclusion. The use of explanations was measured by the total number of explanations that were used for each of the conclusions. The

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>D.F.</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Agreement Main Effect</td>
<td>1</td>
<td>2.93</td>
<td>0.09</td>
</tr>
<tr>
<td>User Expertise Main Effect</td>
<td>1</td>
<td>1.41</td>
<td>0.24</td>
</tr>
<tr>
<td>Interaction Effect</td>
<td>1</td>
<td>1.05</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Table 6.11: ANOVA Results and Summary Statistics of the Number of Explanations Used for the Levels of User Agreement by User Expertise
unit of analysis for this model was each conclusion that was presented by the KBS to the user. Each subject was presented with all 25 of the KBS conclusions.

Table 6.11 presents the results of the model and the means and standard deviations for the number of explanations used. While there was a relationship between the level of user agreement and the use of explanations at the 0.09 significance level, neither the user expertise main effect nor its interaction effect with the level of user agreement was significant. Overall, novices used an average of 0.84 explanations for each conclusion that was presented to them by the KBS, while experts used an average of 0.79 explanations.

Figure 6.10 presents the nature of the significant relationship between the level of user agreement and the use of explanations. This suggests that there is only partial support for the inverse relationship postulated in hypothesis $H_8$. The inverse relationship is observed only between a user agreement level of 1, which signifies a high level of agreement with the KBS, and 4 which signifies the mid-point of the scale, i.e., a situation where the user neither agrees nor disagrees strongly with the KBS. For the remaining half of the scale that signifies a decreasing level of user agreement with a KBS (levels 4 to 7), the use of explanations declines as the level of user agreement declines. Figure 6.11 shows that this same relationship holds for both the expert and novice subjects, with one exception. This is for novice subjects between the user agreement levels of 6 and 7, when the use of explanations increased. It is caused by the fact that there was a sample size of one for this level of agreement (7) among novice subjects, i.e., there was only one instance of a novice subject strongly disagreeing with a KBS conclusion. In this instance, only one explanation was used and the standard deviation was therefore zero (See Table 6.11). Figure 6.11 also confirms
Figure 6.10: Level of Agreement and Explanation Usage

Figure 6.11: User Expertise by Level of User Agreement
the non significant ANOVA results obtained for the user expertise main effect and the interaction effect (Table 6.10) of Model 1. There is no significant difference in the explanation use behavior of novices and experts for varying levels of user agreement.

To further validate the moderating effect of the level of user agreement on the relationship between user expertise and the use of KBS explanations, Hypothesis H10 of Table 6.10 was evaluated using Model 2. This model uses the level of user agreement as the dependent variable and directly tests for differences in the level of user agreement among experts and novices. Explanation provision strategy, which was the other independent variable of the study, was also included as a predictor variable in the model. It had four levels: no explanations provided, only feedforward explanations provided, only feedback explanations provided, and both feedforward and feedback explanations provided. Table 6.12 presents the means and standard deviations of the level of user agreement for the treatment groups of the study. ANOVA analysis of Model 2 indicated that there were no significant differences in the level of user agreement among experts and novices ($F = 1.72$ and $p$-value $= 0.19$). This result provides support for hypothesis H10. The results for explanation provision strategy ($F = 1.03$, $p = 0.38$) and the user expertise by explanation provision strategy
interaction ($F = 1.82, p = 0.14$) were also not significant. As these suggest that the level of user agreement is not influenced by user expertise and/or explanation provision strategy, it indicates that the chances of the level of user agreement exercising a moderating effect are slight.

In summary, the results for this section indicate that: 1) the level of user agreement is a significant determinant of the use of KBS explanations; 2) the influence of user agreement on the use of explanations takes the form of an inverted "U-shaped" curve [Miller and Gordon, 1975; Schroder and Streufert, 1966], and 3) the level of user agreement was not significantly different between experts and novices. There was no evidence of user agreement having a moderating influence on the relationship between user expertise and the use of explanations.

### 6.5 Results Relating to the Effects of the Use of Explanations

The effort involved in the development of an explanation facility for a KBS can only be justified if there are significant benefits accruing to users from the use of the explanations. These benefits could be direct such as improvements in the accuracy of judgmental decision-making, as well as indirect in the sense of more positive user perceptions of usefulness with or without corresponding improvements in accuracy. This study investigated both these two consequences of the use of KBS explanations. For the accuracy of judgmental decision-making, two dependent variables were used: the accuracy of evaluative judgments and the accuracy of predictive judgments. As well, there were two dependent variables for user perceptions of usefulness: the usefulness of the KBS as a whole and the usefulness of the explanations that were provided by the KBS. The next two sections present the findings in relation to the accuracy of judgmental decision-making. Sections 6.5.3 and 6.5.4 then present the findings relating to the impact on user perceptions of usefulness.
6.5.1 Effects of the Use of Feedback/Feedforward Explanations on Accuracy of Judgments

H11a: The use of feedforward explanations will improve the accuracy of judgments.

H11b: The use of feedback explanations will improve the accuracy of judgments.

H12a: The use of Why explanations will improve the accuracy of judgments.

H12b: The use of How explanations will improve the accuracy of judgments.

H12c: The use of Strategic explanations will improve the accuracy of judgments.

Statistical Models Used to Investigate Hypotheses

Model 1: \[ \text{ACCURACY} = B_0 + B_1(\text{FFUSE}) + B_2(\text{FBUSE}) + B_3(\text{UE}) + B_4(\text{FFUSE} \times \text{FBUSE}) + B_5(\text{FFUSE} \times \text{UE}) + B_6(\text{FBUSE} \times \text{UE}) + B_7(\text{FFUSE} \times \text{FBUSE} \times \text{UE}) + e \]

Model 2: \[ \text{ACCURACY} = B_0 + B_1(\text{FFUSE}) + B_2(\text{EPS}) + B_3(\text{UE}) + B_4(\text{FBUSE} \times \text{EPS}) + B_5(\text{FFUSE} \times \text{UE}) + B_6(\text{EPS} \times \text{UE}) + B_7(\text{FFUSE} \times \text{EPS} \times \text{UE}) + e \]

Model 3: \[ \text{ACCURACY} = B_0 + B_1(\text{FBUSE}) + B_2(\text{EPS}) + B_3(\text{UE}) + B_4(\text{FBUSE} \times \text{EPS}) + B_5(\text{FBUSE} \times \text{UE}) + B_6(\text{EPS} \times \text{UE}) + B_7(\text{FBUSE} \times \text{EPS} \times \text{UE}) + e \]

Model 4: \[ \text{ACCURACY} = B_0 + B_1(\text{FFWhy}) + B_2(\text{FFHow}) + B_3(\text{FFStrategic}) + B_4(\text{EPS}) + B_5(\text{UE}) + B_6(\text{Interactions With EPS}) + B_7(\text{Interactions With UE}) + e \]

Model 5: \[ \text{ACCURACY} = B_0 + B_1(\text{FBWhy}) + B_2(\text{FBHow}) + B_3(\text{FBStrategic}) + B_4(\text{EPS}) + B_5(\text{UE}) + B_6(\text{Interactions With EPS}) + B_7(\text{Interactions With UE}) + e \]

Legend: \( B \) = Coefficients \( e \) = Error Term

FFUSE = Proportions of Feedforward Explanations (FF) Used
FBUSE = Proportions of Feedback Explanations (FB) Used
EPS = Explanation Provision Strategy: Provided Alone or Provided Together
UE = Expert and Novice Levels of User Expertise

Figure 6.13: Hypotheses and Statistical Models Relating to the Influence of the Use of KBS Explanations on the Accuracy of Judgments

Figure 6.13 shows the research hypotheses relating to the influence of the use of KBS explanations on the accuracy of judgmental decision-making. There were two sets of hypotheses
corresponding to the classification of measures used for the use of explanations (See Figure 5.2 of Chapter 5). Hypotheses 11a and 11b relate to the influence of the use of explanations provided either as feedback or feedforward. Hypotheses 12a, 12b, and 12c relate to the influence of the use of the three types of explanations that were provided, i.e., the Why, How, and Strategic explanations. Five statistical models were used to test these hypotheses and each model was fitted separately for the two dependent variables --- accuracy of evaluative judgments and the accuracy of predictive judgments. The results of Models 1, 2 and 3 of Figure 6.13, which were used to investigate hypotheses H11a and H11b, are presented in this section. The results of Models 4 and 5, which tested hypotheses H12a, H12b, and H12c, are presented in the next section (Section 6.5.2).

Model 1 was the overall model used to test the influence of the use of feedforward and feedback explanations on the accuracy of judgments. It was run as an ANOVA model on the data collected from all the 80 subjects. User expertise was treated as a categorical variable in the model with two levels --- experts and novices. Explanation provision strategy was not included in the model as a categorical variable. Instead, the proportions of feedforward and feedback explanations used were included in the model as predictor variables. This was done for three reasons. First, the hypotheses relating to the influence of KBS explanations on the accuracy of judgments, as presented in Figure 6.13, focus on the use of these explanations and not their provision. Second, the provision of feedforward or feedback explanations does not lead to all these explanations being used. Third, initial tests, that treated the provision of feedforward and feedback explanations as binary variables, revealed that there were insignificant differences in accuracy between the various treatment groups for explanation provision strategy. The effects of providing feedforward and feedback explanations
Table 6.14A: Influence on Judgmental Accuracy: Results for Model 1

<table>
<thead>
<tr>
<th>EFFECTS (N = 80)</th>
<th>Accuracy of Evaluative Judgments (R^2 = 0.16)</th>
<th>Accuracy of Predictive Judgments (R^2 = 0.06)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>P-Value</td>
</tr>
<tr>
<td>Feedforward Explanations Used (FFUSE)</td>
<td>0.09</td>
<td>0.77</td>
</tr>
<tr>
<td>Feedback Explanations Used (FBUSE)</td>
<td>3.85</td>
<td>0.05</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>5.83</td>
<td>0.02</td>
</tr>
<tr>
<td>FFUSE by FBUSE Interaction</td>
<td>0.59</td>
<td>0.45</td>
</tr>
<tr>
<td>FFUSE by UE Interaction</td>
<td>3.62</td>
<td>0.06</td>
</tr>
<tr>
<td>FBUSE by UE Interaction</td>
<td>0.37</td>
<td>0.55</td>
</tr>
<tr>
<td>FFUSE by FBUSE by UE Interaction</td>
<td>2.55</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Table 6.14B: Influence on Judgmental Accuracy: Results for Models 2 and 3

<table>
<thead>
<tr>
<th>EFFECTS (N = 40)</th>
<th>Feedforward Explanations Used (Model 2)</th>
<th>Feedback Explanations Used (Model 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evaluative Judgments (R^2 = 0.24)</td>
<td>Predictive Judgments (R^2 = 0.17)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Explanations Used (USE)</td>
<td>0.22</td>
<td>0.64</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>0.05</td>
<td>0.83</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>3.86</td>
<td>0.06</td>
</tr>
<tr>
<td>USE by EPS Interaction</td>
<td>0.08</td>
<td>0.79</td>
</tr>
<tr>
<td>USE by UE Interaction</td>
<td>1.06</td>
<td>0.31</td>
</tr>
<tr>
<td>EPS by UE Interaction</td>
<td>0.07</td>
<td>0.80</td>
</tr>
<tr>
<td>USE by EPS by UE Interaction</td>
<td>2.71</td>
<td>0.11</td>
</tr>
</tbody>
</table>
individually or together, as well as their interactions with the amount of explanations used, are however considered in Models 2 through 5 which are discussed later.

The results of Model 1 are presented in Table 6.14A. The use of feedforward explanations did not have a significant effect on the accuracy of either evaluative or predictive judgments. The use of feedback explanations, however, had a significant impact on the accuracy of the evaluative judgments ($F = 3.85, p = 0.05$), but no effect on the accuracy of the predictive judgments. The relationship between the use of the feedback explanations and the accuracy of the evaluative judgments is presented in Figure 6.13A. As accuracy was measured by deviations from correct
scores, it shows that as the use of feedback explanations increased, the deviations from the correct scores declined, i.e., there was an improvement in accuracy. For the purposes of comparison, Figure 6.13A also shows the base or mean accuracy level that was obtained by the subjects who were not provided with any explanations. It shows that a certain threshold of feedback explanations had to be used before an improvement in accuracy could be assured. The interaction between the use of feedforward and feedback explanations was not significant for both the two dependent variables. Thus, while there was no support for hypothesis H11a which tested the use of feedforward explanations, hypothesis H11b which tested the use of feedback explanations was supported in relation to evaluative judgments.

Table 6.14A also shows two other significant factors that influenced the accuracy of evaluative judgments --- the user expertise main effect ($F = 5.83, p = 0.02$), and the interaction between user expertise and the use of feedforward explanations ($F = 3.62, p = 0.06$). Experts, with a mean deviation in accuracy of 8.28, were significantly more accurate than novices, who had a mean deviation of 10.28. The interaction between user expertise and the use of feedforward explanations is shown in Figure 6.13C. The contrasting slopes of the two plots indicate that the increased use of feedforward explanations had a dissimilar impact on the accuracy of experts and novices. While the accuracy of novices improved as more feedforward explanations were used, the accuracy of experts declined as higher proportions of feedforward explanations were used.

Models 2 and 3 specifically investigated the impact of feedforward and feedback explanations being provided alone or together (explanation provision strategy). Model 3 focused on the use of feedback explanations. It differed from Model 1 in two respects. First, subjects in the control
Figure 6.13C: Expert-Novice Differences In the Influence of the Use of Feedforward Explanations on the Accuracy Of Judgments

Legend of Plots
- Experts
- Novices

groups, who did not use any feedback explanations because they were not provided with them, were not included in Model 3 (N = 40). Second, explanation provision strategy was included as an independent variable with two levels: feedback explanations provided alone and feedback explanations provided together with feedforward explanations. Model 2 was similar to Model 3, with the exception that it focused on the use of feedforward explanations instead of the use of feedback explanations and was run on the data from the 40 subjects who received feedforward explanations. Both were run as ANOVA models as explanation provision strategy and user expertise were categorical variables. The use of the explanations was treated as a covariate in the models.
The results of these models are presented in Table 6.14B. They provide evidence of: 1) a significant relationship between the use of feedback explanations and the accuracy of judgments ($F = 3.74$, $p = 0.06$ for evaluative judgments; and $F = 3.26$, $p = 0.08$ for predictive judgments), and 2) no such relationship for the use of feedforward explanations. Figure 6.13B presents plots of the two significant relationships relating to the use of the feedback explanations. These suggest that as the use of feedback explanations increased, the accuracy of both evaluative and predictive judgments increased. For comparison purposes, Figure 6.13B also shows the base levels of accuracy that were achieved by subjects who did not use any explanations at all. These were a mean proportion of 0.31 for predictive judgments and a mean of 9.15 for evaluative judgments. The plot
shows that a larger threshold, i.e. higher proportion, of feedback explanations had to be used to be assured of an improvement in the accuracy of predictive judgments, as compared to an improvement in the accuracy of evaluative judgments. The results of Models 2 and 3 (Table 6.14B) that related to explanation provision strategy were generally not statistically significant, suggesting that it did not matter whether the feedforward and feedback explanations were provided alone or together. The one exception to this, was Model 2 in relation to the accuracy of predictive judgments. Both the explanation provision strategy main effect ($F = 3.31, p = 0.08$) and its interaction with the use of feedforward explanations ($F = 3.38, p = 0.08$) were significant. Subjects provided with only feedforward explanations (mean deviance = 0.23) performed more accurately than subjects provided with both feedforward and feedback explanations (mean deviance = 0.26).

In summary, Models 2 and 3 provide evidence to support hypothesis H11b. The use of feedback explanations does improve the accuracy of judgments.

6.5.2 Effects of the Types of Explanations Used on the Accuracy of Judgments

Model 4 and 5 of Figure 6.13 were used to test the three hypotheses (Hypotheses 12a, b and c) relating to the types of explanations that were used. As with Models 2 and 3, they focused on either the use of feedforward (Model 4) or feedback (Model 5) explanations. Besides the proportions of the Why, How, and Strategic explanations used either as feedforward and feedback, user expertise, explanation provision strategy and their interactions with the types of explanations used were also included as predictor variables in the two models. Explanation provision strategy tested if providing feedforward or feedback explanations alone or together was a factor influencing the relationship between the use of the three types of explanations and the accuracy of the judgments.
Table 6.15: Influence of the Types of Explanations on Judgmental Accuracy: Results for Models 4 and 5

<table>
<thead>
<tr>
<th>EFFECTS (N = 40)</th>
<th>Feedforward Explanations Used (Model 4)</th>
<th>Feedback Explanations Used (Model 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evaluative Judgments (R² = 0.26)</td>
<td>Predictive Judgments (R² = 0.22)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Why Explanations Used</td>
<td>0.00</td>
<td>0.98</td>
</tr>
<tr>
<td>HOW Explanations Used</td>
<td>0.63</td>
<td>0.44</td>
</tr>
<tr>
<td>Strategic Explanations Used</td>
<td>0.53</td>
<td>0.47</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>0.01</td>
<td>0.92</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>3.92</td>
<td>0.06</td>
</tr>
<tr>
<td>Why by EPS</td>
<td>1.92</td>
<td>0.18</td>
</tr>
<tr>
<td>How by EPS</td>
<td>2.12</td>
<td>0.16</td>
</tr>
<tr>
<td>Strategic by EPS</td>
<td>0.39</td>
<td>0.54</td>
</tr>
<tr>
<td>Why by UE</td>
<td>0.78</td>
<td>0.39</td>
</tr>
<tr>
<td>How by UE</td>
<td>1.36</td>
<td>0.25</td>
</tr>
<tr>
<td>Strategic by UE</td>
<td>1.74</td>
<td>0.20</td>
</tr>
</tbody>
</table>

The results of the models are presented in Table 6.15 in relation to the accuracy of both the evaluative and predictive judgments. Of the three types of explanations, only the Why explanation when used as feedback had a significant relationship with the accuracy of predictive judgments (F = 12.40, p < 0.001). Figure 6.14 plots the nature of this relationship. The greater use of the Feedback-Why explanations led to improved accuracy in predictive judgments. The results also indicate that explanation provision strategy and its interactions with the three types of explanations...
were not significant factors influencing the accuracy of judgments. Thus, while the results for Models 4 and 5 provide no evidence supporting hypotheses H12b and H12c, there is some evidence to support hypothesis H12a. The use of the Why explanation provided as feedback does improve the accuracy of predictive judgments.

In summary, the results pertaining to the influence of the use of KBS explanations on the accuracy of judgmental decision-making, suggest that the use of feedback explanations, especially the Why explanation, does result in improved judgmental accuracy.
6.5.3 Effects of the Use of Feedforward/Feedback Explanations on Perceptions of Usefulness

Figure 6.15 presents the research hypotheses pertaining to the influence of the use of KBS explanations on user perceptions of 1) the KBS and 2) the explanations provided by the KBS.

H13a: The use of feedforward explanations will improve user perceptions of usefulness.

H13b: The use of feedback explanations will improve user perceptions of usefulness.

H14a: The use of Why explanations will improve user perceptions of usefulness.

H14b: The use of How explanations will improve user perceptions of usefulness.

H14c: The use of Strategic explanations will improve user perceptions of usefulness.

Statistical Models Used to Investigate Hypotheses

Model 1: \[ \text{USEFULNESS} = B_0 + B_1(\text{FFUSE}) + B_2(\text{FBUSE}) + B_3(\text{UE}) + B_4(\text{FFUSE} \times \text{FBUSE}) + B_5(\text{FFUSE} \times \text{UE}) + B_6(\text{FBUSE} \times \text{UE}) + B_7(\text{FFUSE} \times \text{FBUSE} \times \text{UE}) + e \]

Model 2: \[ \text{USEFULNESS} = B_0 + B_1(\text{FFUSE}) + B_2(\text{FBUSE}) + B_3(\text{EPS}) + B_4(\text{FFUSE} \times \text{EPS}) + B_5(\text{FFUSE} \times \text{UE}) + B_6(\text{FBUSE} \times \text{EPS} \times \text{UE}) + e \]

Model 3: \[ \text{USEFULNESS} = B_0 + B_1(\text{FBUSE}) + B_2(\text{EPS}) + B_3(\text{UE}) + B_4(\text{FBUSE} \times \text{EPS}) + B_5(\text{FBUSE} \times \text{UE}) + B_6(\text{EPS} \times \text{UE}) + B_7(\text{FBUSE} \times \text{EPS} \times \text{UE}) + e \]

Model 4: \[ \text{USEFULNESS} = B_0 + B_1(\text{FFWhy}) + B_2(\text{FFHow}) + B_3(\text{FStrategic}) + B_4(\text{EPS}) + B_5(\text{UE}) + B_6(\text{Interactions With EPS}) + B_7(\text{Interactions With UE}) + e \]

Model 5: \[ \text{USEFULNESS} = B_0 + B_1(\text{FBWhy}) + B_2(\text{FBHow}) + B_3(\text{FBSStrategic}) + B_4(\text{EPS}) + B_5(\text{UE}) + B_6(\text{Interactions With EPS}) + B_7(\text{Interactions With UE}) + e \]

Legend: \( B_n = \text{Coefficients} \quad e = \text{Error Term} \)

\( \text{FFUSE} = \text{Proportions of Feedforward Explanations (FF) Used} \)

\( \text{FBUSE} = \text{Proportions of Feedback Explanations (FB) Used} \)

\( \text{EPS} = \text{Explanation Provision Strategy: Provided Alone or Provided Together} \)

\( \text{UE} = \text{Expert and Novice Levels of User Expertise} \)

Figure 6.15: Hypotheses and Statistical Models Relating to the Influence of the Use of KBS Explanations on User Perceptions of Usefulness
Hypotheses 13a and 13b investigated the impact of the use of feedforward and feedback explanations on these user perceptions of usefulness. Statistical models 1, 2, and 3 were used to test these hypotheses and their results are presented in this section. Hypotheses 14a, 14b, and 14c investigated the impact of the use of the Why, How, and Strategic types of explanations on the same two user perceptions of usefulness. Statistical models 4 and 5 were used to test them, and their results are discussed in Section 6.5.4.

Model 1 was the primary model used to test hypotheses H13a and H13b. It represents an ANOVA model with FFUSE and FBUSE being the respective proportions of the feedforward and feedback explanations that were used by subjects. The criterion variable (USEFULNESS) was measured by summing the values of multiple items that comprised a seven-point, Likert-type scale. A smaller sum for this measure indicates a more positive perception of usefulness than a larger sum, and vice versa. The data of all the 80 subjects of the study was used for evaluating the model in relation to the perceptions of usefulness of the KBS. For the perceptions of usefulness of the explanations provided, the model was run using a sample size of only 60. Measurements of this dependent variable were not collected from the 20 subjects in the control groups who were not provided with any explanations. The results of the model are presented in Table 16.17A. The use of feedforward explanations was found to be a significant predictor of user perceptions of the usefulness of the explanations provided (F = 3.36, p = 0.07). Figure 6.16A shows the plot of this significant relationship. User perceptions of usefulness of the explanations improved as the proportion of feedforward explanations used increased. However, this relationship was not statistically significant in relation to the use of feedback explanations, for user perceptions of the usefulness of the KBS and the explanations.
Table 6.17A: Influence on User Perceptions of Usefulness: Results for Model 1

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>Usefulness of the KBS (N = 80; R² = 0.11)</th>
<th>Usefulness of Explanations (N = 60; R² = 0.12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>P-Value</td>
</tr>
<tr>
<td>Feedforward Explanations Used (FFUSE)</td>
<td>0.71</td>
<td>0.40</td>
</tr>
<tr>
<td>Feedback Explanations Used (FBUSE)</td>
<td>0.60</td>
<td>0.44</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>0.29</td>
<td>0.59</td>
</tr>
<tr>
<td>FFUSE by FBUSE Interaction</td>
<td>1.06</td>
<td>0.31</td>
</tr>
<tr>
<td>FFUSE by UE Interaction</td>
<td>1.67</td>
<td>0.20</td>
</tr>
<tr>
<td>FBUSE by UE Interaction</td>
<td>0.09</td>
<td>0.77</td>
</tr>
<tr>
<td>FFUSE by FBUSE by UE Interaction</td>
<td>0.98</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Table 6.17B: Influence on User Perceptions of Usefulness: Results for Models 2 and 3

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>Feedforward Explanations Used (USE) (Model 2)</th>
<th>Feedback Explanations Used (USE) (Model 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Usefulness of the KBS (R² = 0.26)</td>
<td>Usefulness of Explanations (R² = 0.16)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Explanations Used (USE)</td>
<td>2.82</td>
<td>0.10</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>3.91</td>
<td>0.06</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>0.25</td>
<td>0.62</td>
</tr>
<tr>
<td>USE by UE Interaction</td>
<td>2.99</td>
<td>0.09</td>
</tr>
<tr>
<td>USE by EPS Interaction</td>
<td>0.09</td>
<td>0.76</td>
</tr>
<tr>
<td>EPS by UE Interaction</td>
<td>0.56</td>
<td>0.46</td>
</tr>
<tr>
<td>USE by EPS by UE Interaction</td>
<td>2.18</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Models 2 and 3 were run primarily to assess the differential impact of explanation provision strategy, i.e., providing feedforward and feedback explanations alone as compared to providing them together. Model 2 compared the groups who received only feedforward explanations to the groups receiving both feedforward and feedback explanations. The groups which did not receive feedforward explanations (the control groups and the groups receiving only feedback explanations) were excluded from this analysis. Similarly, Model 3 compared the groups who received only feedback explanations to the groups receiving both feedforward and feedback explanations. The groups which did not receive feedback explanations (the control groups and the groups receiving only feedback explanations) were excluded from this analysis.
The results of the two models are presented in Table 6.17B. They show that there is a significant relationship between the use of feedforward explanations and user perceptions of both the usefulness of the explanations ($F = 3.32, p = 0.08$) and the usefulness of the KBS ($F = 2.82, p = 0.10$). Figure 6.16B shows the nature of these significant relationships. The slopes of the two plots suggest that the increased use of feedforward explanations leads to users perceiving the KBS and its explanations as being more useful. The results of Model 3 pertaining to the influence of the use of feedback explanations on user perceptions of usefulness were not significant.
Another result of Model 2 was the significant difference in user perceptions of the usefulness of the KBS between subjects who received only feedforward explanations and those who received both feedforward and feedback explanations ($F = 3.91, p = 0.06$). Table 6.18 shows the mean user perceptions of KBS usefulness for these two levels of explanation provision strategy. Subjects who received only feedforward explanations perceived the KBS as being more useful (mean score = 16.45) than subjects who received both feedforward and feedback explanations (mean score = 19.2). The significant result for the explanation provision strategy by the use of feedforward explanations interaction ($F = 2.99, p = 0.09$) provides an explanation for this result. This is shown in Figure 6.17A. Subjects who were provided with both feedforward and feedback explanations used 5.8% of the feedforward explanations provided as compared to the 7.4% used by subjects provided with only feedforward explanations. Considering that there were no other differences between the two groups, this suggests that tradeoffs made by subjects between the use of feedforward explanations and the use of feedback explanations, could possibly be the cause of the poorer

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Explanation Provision Strategy</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FF Alone</td>
<td>Both</td>
</tr>
<tr>
<td>Feedforward Explanations Used</td>
<td>(as a % of total provided)</td>
<td>7.4</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>(std. dev.)</td>
<td>(7.2)</td>
<td>(6.4)</td>
</tr>
<tr>
<td>Feedback Explanations Used</td>
<td>(as a % of total provided)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(std. dev.)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Usefulness of the KBS</td>
<td></td>
<td>16.45</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td>(std. dev.)</td>
<td>(7.2)</td>
<td>(7.34)</td>
</tr>
</tbody>
</table>
perceptions of the usefulness of the KBS. This result is also consistent with the finding that user perceptions of the usefulness of the KBS increase with the use of feedforward explanations.

The results for Model 3 also show a significant difference in the perceptions of KBS usefulness between subjects provided with only feedback explanations and those provided with both feedforward and feedback explanations (F = 4.93, p = 0.06). Table 6.18 shows that subjects provided with both feedforward and feedback explanations perceived the KBS as being less useful as compared to subjects who only received feedback explanations. Similar to the Model 2 result that was discussed in the last paragraph, this can be explained by the significant explanation provision strategy by use of feedback explanations interaction effect (F = 5.17, p = 0.03). Figure 6.17B shows the nature of this interaction and the relevant means and standard deviations are provided in Table 6.18.

In summary, the results of Models 1, 2 and 3 of Figure 6.15 suggest that: 1) the use of feedforward explanations improves user perceptions of the usefulness of both the KBS and the explanations provided; 2) the tradeoffs between feedforward and feedback explanations that subjects have to make when provided with both feedforward and feedback explanations lead to poorer perceptions of the usefulness of the KBS than if feedforward or feedback explanations were provided alone.

### 6.5.4 Effects of the Types of Explanations Used on Perceptions of Usefulness

Models 4 and 5 of Figure 6.15 were used to test the three hypotheses relating to the three types of explanations (H14a, b, and c). They also focused on the influence of the two levels of
Figure 6.17A: Plots of Feedforward (FF) Explanations Used and User Perceptions of KBS Usefulness By Explanation Provision Strategy

Legend of Plots
- Usefulness of KBS
- FF Explanations Used

(Model 2)

Figure 6.17B: Plots of Feedback (FB) Explanations Used and User Perceptions of KBS Usefulness By Explanation Provision Strategy

Legend of Plots
- Usefulness of KBS
- FB Explanations Used

(Model 3)
explanation provision strategy (EPS), i.e., feedforward or feedback explanations provided alone or together, and their interactions with the three types of explanations. Model 4 was run using the data from all subjects who were provided with feedforward explanations, while Model 5 on the data from all subjects who were provided with feedback explanations. The results of these ANOVA models are provided in Table 6.19. All three of the Why, How, and Strategic types of explanations were found to be a statistically insignificant as predictors of user perceptions of usefulness. There was

<table>
<thead>
<tr>
<th>EFFECTS</th>
<th>Feedforward Explanations Used (Model 4)</th>
<th>Feedback Explanations Used (Model 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Usefulness of the KBS (R² = 0.27)</td>
<td>Usefulness of Explanations (R² = 0.15)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Why Explanations Used</td>
<td>0.23</td>
<td>0.64</td>
</tr>
<tr>
<td>How Explanations Used</td>
<td>0.99</td>
<td>0.33</td>
</tr>
<tr>
<td>Strategic Explanations Used</td>
<td>0.07</td>
<td>0.80</td>
</tr>
<tr>
<td>Explanation Provision Strategy (EPS)</td>
<td>5.26</td>
<td>0.03</td>
</tr>
<tr>
<td>User Expertise (UE)</td>
<td>0.00</td>
<td>0.95</td>
</tr>
<tr>
<td>Why by EPS</td>
<td>0.04</td>
<td>0.85</td>
</tr>
<tr>
<td>How by EPS</td>
<td>0.21</td>
<td>0.65</td>
</tr>
<tr>
<td>Strategic by EPS</td>
<td>0.90</td>
<td>0.35</td>
</tr>
<tr>
<td>Why by UE</td>
<td>0.07</td>
<td>0.80</td>
</tr>
<tr>
<td>How by UE</td>
<td>0.00</td>
<td>0.95</td>
</tr>
<tr>
<td>Strategic by UE</td>
<td>0.27</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 6.19: Influence of the Types of Explanations on Perceptions of Usefulness: Results for Models 4 and 5
therefore no support for hypothesis H14a, H14b, and H14c of Figure 6.15. Explanation provision strategy was found to be statistically significant in relation to user perceptions of the KBS for both Models 4 and 5. This result was analyzed earlier in relation to Models 2 and 3 in the last section. None of the interactions of explanation provision strategy and the three types of explanations was significant at the 0.10 level.

In summary, the results of Models 4 and 5 suggest that there is no evidence that the use of any of the three types of explanations or their interactions with explanation provision strategy have an impact on user perceptions of usefulness.

6.6 Results of Other Statistical Analysis Undertaken

This section reports the results of two other sets of analyses that were performed. Section 6.6.1 reports on the structural equation modelling [Bagozzi, 1977] that was undertaken to supplement the main statistical analysis. The following section will present the results of various other tests that were performed to control for extraneous factors that might have influenced the results.

6.6.1 Results of Structural Equation Modelling

The primary advantage offered by the use of structural equation modelling is that the analysis of the determinants of the use of KBS explanations (discussed in Section 6.3) could be combined with the analysis of the consequences of the use of KBS explanations (discussed in Section 6.5). By combining all the determinants and consequences into one structural equation model, overall measurement error was minimized. This could not be done using the first-generation
statistical techniques [Fornell, 1982], such as multiple regression and the analysis of variance, because the use of KBS explanations served as the dependent variable in the analysis of the determinants and as the independent variable in the analysis of the consequences. The Partial Least Squares (PLS) method [Wold, 1979; Lohmoller, 1982] of structural equation modelling was used to perform the analysis instead of the linear structural relationships (LISREL) model [Joreskog and Sorbom, 1984]. A comparison of these alternative models for structural equation modelling and the reasons for the selection of PLS are provided in Appendix 8.

Two sets of models were fitted. The first was an overall model, as presented in Figure 6.19, that was fitted using the data obtained from all 80 subjects. All the relationships that were hypothesized in this study were included as paths between the latent variables in this model. The structure of this model and its test are discussed in this section in relation to the findings from the earlier sections of this chapter. The second model was fitted separately for the different treatment levels of the explanation provision strategy variable. It was felt that this would more accurately reflect the fact that some subjects had no scores for the use of feedforward and feedback explanations because they were not provided with these explanations. The results of this second model are presented and discussed in Appendix 8 as they do not go beyond the results of the first model in clarifying the hypothesized relationships of the study. This is largely because PLS does not provide any goodness-of-fit indices or other procedures that would facilitate the comparison of multiple models representing different treatment levels.

Figure 6.19 shows the composition and results of the overall structural equation model that was fitted. Three of the five latent variables, namely user expertise, explanation use, and

* significant at p < 0.05
explanation provision strategy, were modelled using formative indicators. Explanation provision strategy is "formed" by two binary indicators: feedforward and feedback. Explanation use is "formed" by the six possible combinations of the three types of explanations (Why, How, and Strategic) with the feedforward (FF) and feedback (FB) methods of explanation provision. It can be considered to be an index composed of these six indices. User expertise is considered to be defined or "formed" by its two measurements, years of experience and professional qualifications, in contrast to considering these measurements to be 'reflectors' of the user expertise. This later approach would have been appropriate if user expertise had been operationalized using specific measures of expert task performance, such as percentages of correct predictions or diagnoses made.

The two latent variables representing the consequences of the use of explanations are modelled using reflective indicators. Thus, the accuracy of judgments is considered to be reflected in the eight deviance scores used as measurements, one for each judgment that was made. It was also possible to combine the six evaluative judgments with the two predictive judgments in this model. Nine reflective indicators of user perceptions of the usefulness of the explanations were used. These represent the nine items of the scale that was used to measure these perceptions. The items of the scale measuring user perceptions of the usefulness of the KBS were not included in an effort to reduce the complexity of the model. For this same reason and because the unit of analysis of the data relating to the level of user agreement was each conclusion that the KBS presented instead of each individual subject, the level of user agreement with the KBS was also excluded from the model. The model yielded three sets of results that were analyzed. These are the path coefficients that represent the hypothesized causal relationships between the latent variables, the multiple $R^2$ measures for the endogenous latent variables, and the results of the measurement models for each of the latent variables.
The path coefficients of the model can be interpreted as being equivalent to the standardized beta weights in a multiple regression model [Gopal, Chin and Bostrom, 1992], with the magnitude of the coefficients indicating whether the relationship represented by the path was negligible or noteworthy. In Figure 6.19, the most notable relationship was the path between explanation provision strategy and explanation use, with a coefficient of 0.727. This suggests a strong relationship between the provision of KBS explanations and their use by users, and provides a positive response to the fundamental, albeit uninvestigated, question that has been posed by researchers of KBS explanations: "Are explanation capabilities being utilized?" [Ye, 1990, p. 164]. The smallest path coefficient (0.014) was the causal relationship between user expertise and the use of explanations, suggesting that they were not related. These results validate those of Section 6.3 that found that the three levels of explanation provision strategy --- only feedforward, only feedback, and both feedforward and feedback, were significant determinants of the use of explanations while user expertise was not. The strengths of the path coefficients of the consequences of the use of explanations were 0.243 for the accuracy of judgments and 0.153 for perceptions of the usefulness of the explanations, suggesting that they are relatively weaker relationships. As well, user expertise had a relatively strong effect on the accuracy of judgments with a path coefficient of 0.57, and a weak effect on user perceptions of usefulness (path coefficient = 0.153).

The significance of these six paths coefficients was tested using the blindfolding technique [Lohmoller, 1984] to calculate the probability of obtaining a particular coefficient if the true value of the coefficient was zero. The results, which are also indicated in Figure 6.19, show that with the exception of the path from user expertise to explanation (t = 0.58, p = 0.34), all five of the other paths were significant at the 0.05 level. The explanation provision strategy to explanation use path
yielded a t-value of 31.32 and p < 0.001. The significant results for the two consequences of the
use of explanations were t = 2.98 and p < 0.01 in relation to the accuracy of judgments; and t =
2.12 and p < 0.01 in relation to user perceptions of the usefulness of the explanations. These
results for the two paths pertaining to the consequences of the use of explanations provide
supporting evidence for the results that were found earlier in Sections 6.5.1 and Sections 6.5.3.
Those results had indicated that only the use of feedback explanations had an impact on accuracy,
while only the use of feedforward explanations had an impact on user perceptions of the usefulness
of the explanations. While these relationships were significantly different from zero in the PLS
model, their importance should however be evaluated in terms of the magnitude of their respective
path coefficients [Gopal, Chin, and Bostrom, 1992]. These suggest that they are relatively weaker
relationships.

The multiple R² values for the endogenous latent variables, that are reported in Figure 6.19,
show the percentage of the variance in the respective latent variables that can be explained by the
overall model proposed. The results suggest that user expertise and explanation provision strategy
explain 53% of the variance in the use of the explanations. Considering that a multiple R² of 53% is
relatively high for a behavioral study [Cohen and Cohen, 1975] and the path from user expertise
to the use of explanations was not statistically significant, this means that the nature and timing of
explanations provided, i.e., explanation provision strategy, mostly accounts for the amount of
explanations that are used. The use of the explanations together with user expertise explained 36%
of the variance in the accuracy of judgments but only 4% of the variance in user perceptions of the
usefulness of the explanations. It was also found that if the path from user expertise to the accuracy
of judgments was not included in the model, the use of explanations explained about 5% of the
variance in the accuracy of judgments. These $R^2$ values are generally consistent with those that were obtained in the regression and ANOVA analysis of the earlier sections. For example, these had revealed that the use of explanations explained 16% of the variance in the accuracy of evaluative judgments (see Table 6.14A), 6% of the variance in the accuracy of the predictive judgments (see Table 6.14A), and 11% of the variance in the user perceptions of the usefulness of the explanations (see Table 6.17A).

The measurement models of the five latent variables were evaluated as to individual item reliability by examining the loadings of the various indicators for the five latent variables. Unlike the path coefficients and the $R^2$ values, this did not directly clarify any of the hypothesized relationships but was useful from the perspective of assessing the internal validity. According to Higgins, Barclay and Duxbury [1991] items with more explanatory power, i.e., higher loadings, are generally accepted in PLS analysis. However, they advise caution in dropping items with low loadings as there can be other reasons underlying low loadings besides low reliability, e.g., multidimensionality of the construct. The loadings for the items used to measure the user perceptions of usefulness of the explanations were generally high for all the items, with the exception of the 0.53 loading for Item 7. This is consistent with the factor loadings, item-to-total correlations, and deletion effects on Cronbach’s ALPHA that were obtained in Section 6.2 (see Table 6.4). The loadings for the accuracy of judgments reveals that judgments 1, 3, and 7 had the highest explanatory power. As per the Judgment Recording Sheets of Appendix 2, judgments 1 and 3 correspond respectively to the evaluative judgments relating to the liquidity and asset utilization aspects of the financial analysis case. Judgment 7 was the predictive judgment relating to the future net income of the company. For the latent variable representing the use of KBS explanations, the
loadings for the six indicator variables were generally high with the exception of the Why explanation provided as feedforward. Both the loadings of the indicators variables used for operationalizing explanation provision strategy were also high.

In summary, the results of the structural equation model as presented in Figure 6.19 support the regression and ANOVA results presented earlier.

6.6.2 Results of Validation Tests

A set of other tests were performed to control for extraneous factors that might have posed threats to the internal validity of the study, as well as to serve as manipulation checks. The ease-of-use of the KBS was assessed to ensure that it was not different for the various levels of explanation provision strategy. User perceptions of their motivation to use the explanations that were provided by the KBS were also assessed to assure that subjects in all treatment groups were equally motivated to use the explanations. User perceptions of the expertise of the system, and of the explanations that were provided, were analyzed to ensure that subjects were convinced they were interacting with a KBS of high quality. As well, the accuracy of the judgments made by subjects before and after using the KBS was also compared to assess the quality of the KBS. Finally, self-reported data of subjects' past familiarity with expert systems was analyzed to ensure that this was not an extraneous influence on the results.

6.6.2.1 Ease of Use of the KBS

Considering that subjects received different variations of the KBS, it was important to assess if this had an influence on their perceptions of the ease-of-use of the KBS. For example, subjects
in the control groups that received no explanations could possibly perceive the KBS as being easier to use than subjects who had both feedforward and feedback explanations provided to them. The validity and reliability of the measures for ease-of-use were discussed earlier in Section 6.2. The 5-item scale used had a Cronbach's ALPHA of 0.76. The 80 subjects who participated had a mean perception of 1.76 on a seven-point Likert-type scale, with 1 signifying the KBS was easy to use and 7 signifying the KBS was not easy to use. While this suggests that the system was generally perceived as being easy to use, it was also necessary to ensure that there were no significant differences between the various treatment groups. A two-factor ANOVA model (with N = 80) was used to test if user expertise and explanation provision strategy were predictors of the ease-of-use of the KBS. The results for user expertise were F = 0.17 and p = 0.89, while the results for explanation provision strategy yielded an F-value of 0.32 and p = 0.81. As well, the 20 subjects who received no explanations had mean perception of 1.74 on the scale, while the 60 who did receive explanations had a mean of 1.76. Thus, there was no evidence that ease-of-use of the KBS was influenced by any one of the treatments in the study.

6.6.2.2 Past Familiarity With KBS

As part of the Background Information Questionnaire (see Appendix 1) that subjects completed after deciding to participate in the study, they reported their familiarity with KBS on a single-item, 10-point scale. A rating of 10 on the scale signified being very familiar with KBS and a rating of 1 signified not being familiar with them. Novices reported a mean level of familiarity of 3.55 on this scale while experts had mean of 2.94. A one-factor ANOVA that was performed revealed that these expert-novice differences in the familiarity with KBS were not significant (F = 1.61, p = 0.21).
6.6.2.3 Motivation to Use the Explanations

Data on the motivation to use the KBS explanations was collected for two reasons. First, it served as a check of the realism of both the experimental task and the interface used for providing the explanations. Second, it served as the basis for post-hoc analysis of subjects who did not use any explanations at all, despite being provided with them. Two items were included in the post-study questionnaire to measure motivation to use the explanations. These were: "I used the explanations provided by FINALYZER-XS adequately," and "I made good use of the explanations provided by FINALYZER-XS." Only the 60 subjects who were provided with explanations provided this data. On the seven-point scales used, with a rating of 1 signifying a high level of motivation to use the explanations, subjects provided a mean rating of 2.86. A two factor ANOVA was performed to test if there were significant differences in motivation among the treatment groups to which subjects belonged. The test results for user expertise were $F = 0.33$ and $p = 0.57$, while those for explanation provision strategy were $F = 0.74$ and $p = 0.48$. They suggest that there were no significant differences in motivation to use the explanations among the treatment groups. As well, evaluation of the motivation score of the one subject who did not use any explanations, when provided with them, did not reveal any significant difference in motivation.

6.6.2.4 Expertise Contained In the KBS

This construct was used to assess if the subjects perceived the expertise of the KBS as being of high quality. Three items included in the post-study questionnaire were used to capture these perceptions. There were: 1) "Many of the conclusions and recommendations generated by FINALYZER-XS could only have been produced by the most experienced financial analysts in industry," 2) "The quality of financial analysis performed by FINALYZER-XS can be rated as
being equivalent to that of the best human experts," and 3) "I am impressed by the level of expertise displayed by FINALYZER-XS." On the seven-point scale used, with a rating of 1 signifying strong agreement with the above three statements, subjects provided a mean rating of 1.40. A two-factor ANOVA found that there were no significant differences in subjects’ perception of the expertise of the KBS both among expert and novice subjects (F = 1.26, p = 0.27), as well as among the four levels of explanation provision strategy (F = 0.97, p = 0.41).

6.6.2.5 Expertise of the Explanations Provided

This construct was used to assess if the subjects perceived the explanations that were provided as being of high quality. Three items included in the post-study questionnaire were used to capture these perceptions. There were: 1) "The explanations provided by FINALYZER-XS could only be provided by the most experienced financial analysts in industry," 2) "The quality of the explanations provided by FINALYZER-XS can be rated as being equivalent to that of the best human experts," and 3) "I am impressed by the level of expertise that is displayed in the explanations provided by FINALYZER-XS." On the seven-point scale used, with a rating of 1 signifying strong agreement with the above three statements, subjects provided a mean rating of 2.06. A two-factor ANOVA found that there were no significant differences in subjects’ perceptions of the expertise contained in the explanations 1) between subjects who received explanations under the three levels of explanation provision strategy (F = 0.36, p = 0.70), and 2) between experts and novices (F = 1.02, p = 0.32).

6.6.2.6 Accuracy of Judgments Before and After Using the KBS

The statistical model presented at the top of Table 6.20 was used to compare subjects’
accuracy of judgments before and after using the KBS. The accuracy of evaluative judgments was assessed separately from the accuracy of the predictive judgments, and judgmental accuracy before and after the "use of the KBS" was treated as a repeated measure in the model. As well, user expertise and its interaction with the use of the KBS were also included in the model to assess if the KBS influenced the novices differently from the experts. The results of the models are presented in Table 6.20 and the relevant means and standard deviations in Table 6.21. The use of the KBS resulted in a significant improvement in subjects accuracy for evaluative judgments (F = 10.30; p
The mean deviance (inaccuracy) in the evaluative judgments made by subjects was reduced by about 13%, i.e. from 10.66 to 9.28, as a result of having used the KBS. In the case of the predictive judgments, the 9.68% reduction in inaccuracy, from a proportion of 0.31 to 0.28, was statistically insignificant ($F = 2.21, p = 0.14$). While these results suggest that the KBS was of sufficient high quality to have a positive impact on the accuracy of judgments, the non-significant improvement in accuracy for predictive judgments was not surprising. The evaluative judgments were directly related to the analysis that the KBS performed and the conclusions it offered. The predictive judgments, however, went a step further in the sense that users had to utilize the analysis and conclusions offered to make predictions. Considering that the KBS did not offer precise estimates for these predictions and that these are often influenced by other factors beyond the scope of the financial analysis that the KBS performed, these judgments were more difficult to make than the evaluative judgments. In retrospect, the accuracy of evaluative judgments was a more direct dependent variable, which had a higher potential to be causally related, for the task and KBS that were used in the study.

The results for user expertise indicated that there was a significant difference between experts and novices for evaluative judgments ($F = 9.55, p = 0.003$), both before and after the use of the KBS. Table 6.21 shows that the experts were more accurate than the novices. The interaction effect of user expertise by the use of the KBS was not statistically significant for both evaluative and predictive judgments. The mean deviance scores of novices dropped 12.5% from 11.75 to 10.28 as a result of using the KBS, while those of the experts dropped 13.6% from 9.58 before using the KBS to 8.28 after using it. The 1.48 absolute improvement in accuracy of novices was larger than the 1.30 of the experts. Thus, while experts were still more accurate than the novices after using
the KBS, the difference in accuracy between them was of a smaller magnitude. This suggests that while the use of the KBS and its explanations reduced the differences in accuracy between experts and novices, it does not completely eliminate them. The accuracy scores of the experts before using the KBS were still significantly better than those of the novices after the use of the KBS.

In summary, it was found that: 1) both experts and novices benefit from the use of a KBS and its explanations, and 2) the use of a KBS and its explanations does not completely eliminate expert-novice differences in accuracy as both improve by about the same rate. These results, while important in themselves, also provide assurance that the quality of the KBS that was used in the study was adequate.

6.7 Summary of the Chapter

This chapter presented all the results of the study in relation to the research hypotheses. Some of the major results relating to the determinants of the use of KBS explanations include: 1) user expertise is not a determinant of the proportion of explanations used but influences the types of explanations that are used, 2) explanation provision strategy is a critical determinant of the use of KBS explanations with feedback explanations being used significantly more than feedforward explanations, 3) the three types of explanations are used in different proportions with the Why and How explanations being used significantly more than the Strategic explanations. It was also found that the level of user agreement with a KBS had an "inverted-U" shaped relationship with the use of explanations. The least number of explanations are used when the level of user agreement is either very high or very low. The major results relating to the impact of the use of explanations include the following: 1) the use of feedback explanations does improve the accuracy of judgmental
decision-making but has no impact on user perceptions of usefulness, 2) the use of feedforward explanations while having no impact on the accuracy of judgments is positively correlated with user perceptions of usefulness, 3) the use of the Why explanation as feedback improves the accuracy of judgmental decision-making. As well, there was also evidence that the explanations provided by the KBS were utilized, and that the use of the KBS benefited both experts and novices. The implications of these and the other findings of the study are discussed in the next chapter.
CHAPTER 7: DISCUSSION OF THE FINDINGS AND CONCLUSION

7.0 Introduction

This chapter discusses the implications of the empirical findings that were presented in Chapter 6. Section 7.1 examines the results pertaining to the factors that influence the use of KBS explanations, as well as the results relating to the effects of the use of the explanations. Considering that an understanding of the use of explanations is a necessary pre-requisite for the development of a theory for the provision of KBS explanations, Section 7.1 also evaluates the feedforward-feedback model for KBS explanation provision (that was proposed in Chapter 2) within the context of the framework for investigating KBS explanations discussed in Chapter 3.

As every research study must deal with a host of conceptual, methodological and resource constraints, many of which have to be resolved by making tradeoffs, such as that between experimental control and generalizability, Section 7.2 addresses the limitations of the experiment that was performed. Section 7.3 discusses the contributions the study makes to how a knowledge-based system should provide explanations to its users. Finally, Section 7.4 suggests various directions for research on KBS explanations and provides prescriptions for future studies of this issue.

7.1 Implications of the Research Findings

The following discussion of the implications of the research findings addresses the three central research questions of the study. The first sub-section focuses on the extent to which KBS
explanations are utilized, the second considers the various factors that influence the use of KBS explanations, and the third evaluates the manner in which the use of the explanations benefits KBS users.

7.1.1 Are KBS Explanations Used in Judgmental Decision-Making Situations?

The study provides clear evidence that explanations are used in situations where a KBS is used as a decision-aid to make complex judgments under conditions of uncertainty. This is an important result considering that prior studies have only demonstrated the use of explanations in laboratory contexts which were either specifically designed so as to induce a strong user need for acquiring explanations in the user-KBS dialogue or where the primary task objective was solely to evaluate the explanations provided rather than to support decision making. For example, Ye [1990] had subjects evaluate explanations provided by a KBS for the purposes of deciding if the KBS should be purchased by their firm, while Lerch et al. [1990] had subjects evaluate the explanations provided, in terms of how much trust they would place in them, with no other decisional performance objective in mind.

The study also provides an indication of the exact level of explanations that are used. As a whole, approximately 16% of the explanations that were provided were used. The fact that not all the explanations provided were used can be explained in relation to the "learning versus working conflict" that was discussed in Chapter 2. In working situations, as learning objectives have to be traded off for performance goals, users did not use all the explanations provided to them. This argument implies that the explanations that were used represent those with the highest perceived relevance to the performance goals.
This result also raises the issue of the relationship between the use of the explanations and the effectiveness of the KBS. A question that can be posed is: "Does the greater use of the explanation facility mean that better problem solving was achieved?". There was subjective evidence, in the form of explicit comments made by subjects, to suggest that by serving as valuable memory-aids, the use of the explanations lead to more complete analysis being performed by some subjects. These subjects would not have considered some aspects of the task problem had the explanations not been available to attract the attention to, and facilitate the consideration of, these aspects. This issue is related to the more general issue in DSS research of whether a decision aid leads decision makers to perform more, and therefore by implication "better", analysis of the task problem [Keen, 1981]. This issue is discussed further in Section 7.1.3.1 which focuses on the effect of the use of explanations on the accuracy of judgmental decision making.

7.1.2 What Factors Influence The Use of KBS Explanations?

The study investigated four specific factors that were hypothesized as influencing the use of explanations. Of these, the study found that explanation provision strategies, the types of explanations, and the level of user agreement with the conclusions of the KBS significantly influenced the use of KBS explanations. However, the level of user expertise did not have such an influence.

7.1.2.1 Influence of Explanation Provision Strategies: Feedforward Versus Feedback

There were two major findings of the influence of the explanation provision strategies. First, in general, feedback explanations were used approximately four times more than feedforward explanations. Second, there was no evidence of an interaction between feedforward and feedback
in terms of use, i.e., each was used just as much when both were provided together or when
provided in isolation.

The significantly greater use of feedback explanations is consistent with recent studies in
decision making that have demonstrated that cognitive feedback is more effective than feedforward
[Sengupta and Abdel-Hamid, 1991]. It is also consistent with the fact that MYCIN's How
explanations, which are in feedback form, are used more than its Why explanations, which are in
feedforward form [Clancey, 1983]. The greater use of feedback explanations could also reflect the
emphasis on performance versus learning in working situations (learning versus working conflict).
This result has important implications for the development of a cognitive learning theory of
explanations. First, any theory of KBS explanations has to take account of the context in which the
KBS is used. The problem-solving context that was utilized in this study resulted in subjects using
more feedback than feedforward explanations. This is because feedback explanations are specific
to the outcomes of a particular problem-solving situation as compared to the more generalized
feedforward explanations. However, it is possible that in instructional situations, where KBS are
used for training purposes, the feedforward explanations will be used more substantially. Future
research should investigate the use of feedforward and feedback explanations by using tasks with
varying levels of emphasis on performance versus learning objectives.

The result that feedback explanations are used more than feedforward explanations also has
an important practical implication for the design of KBS explanations. If one of the goals of KBS
developers is to provide explanations that are of relevance to the performance objectives of KBS
users, then the provision of feedback explanations should be given a higher priority than the
provision of feedforward explanations. This is especially important in a situation where there are limited resources available for developing the explanation facility and decisions have to be made as to which explanations will be given priority.

The second result relating to the lack of an interplay between feedback and feedforward explanations also has important implications. First, contrary to the cognitive learning literature [Bjorkman, 1972] it implies that KBS users regard feedforward and feedback explanations as being significantly different sources of explanatory information rather than as substitutes for each other. Second, it implies that feedforward explanations are used for learning about different aspects of the KBS's representation of the domain knowledge than in the case when feedback explanations are used. This means that the provision of both feedforward and feedback explanations should lead to more learning, than in situations when only one of them is provided.

7.1.2.2 Influence of User Expertise

In contrast to the three past studies of KBS explanations, this study found that user expertise had no effect on the use of explanations and experts used just as many explanations as novices. This result is contrary to the argument that novices will make greater use of explanations as they have more to learn from such explanations. As this argument is largely based on the prescriptions of learning theories for instructional situations, including Anderson’s ACT theory, the result highlights that learning in working situations is significantly different from that in instructional situations. It confirms the earlier assertion in Chapter 2 that theories for instructional situations may not be valid for working situations.
There are several possible reasons for user expertise not being a significant determinant of
the use of explanations. Novices were expected to use more explanations than experts because they
have less developed models of the domain and therefore have more to learn from using the
explanations. Various other reasons can however be identified to account for experts using just as
much explanations as novices. First, it could be argued that the more developed model of the
domain possessed by experts allows them to make greater use of the KBS and its explanations.
Being more confident of their own expertise, they rely less on the KBS and therefore use the
explanations to question its knowledge and functioning. Second, experts may view the KBS as a
competing model of expertise and therefore use the explanation facility to investigate how it is
different from their own. Thus, these arguments suggest that experts could be using the explanations
for a variety of reasons that go beyond the learning objectives that primarily guide novice use of
the explanations.

The significant expert-novice differences that were found by the three past studies of KBS
explanations could possibly be explained by the fact that they used significantly different tasks than
that used in this study. From the perspective of judgmental decision making, the experimental task
used in this study was significantly more complex and "realistic" than those used in the prior
studies. It is highly likely that for the simple and artificial judgmental tasks used in the other
studies, experts may not have been convinced of the need for a KBS of high quality and this may
have resulted in their using a lesser proportion of explanations than novices. In this study, the task
was realistic and complex enough that both experts and novices alike could clearly perceive both
the need for the KBS and the benefits that would accrue from using it. As well, there was also clear
evidence to suggest that the subjects were convinced of the high level of expertise of this KBS.
Experts will use explanations to "challenge" or investigate the knowledge and functioning of a KBS only when the task problem is complex enough to warrant the need for a KBS and when they are convinced that its expertise is of high quality. An interesting area for future research would be to directly test the moderating effect of user perceptions of the quality of the KBS on expert-novice differences in the use of KBS explanations. Thus, unlike the case of the trivial and abstract task situations that were used by other studies, in complex and realistic decision making situations where the need for a KBS of high quality is more evident, experts utilize explanations just as much as novices. This is also consistent with the secondary result of this study, that was discussed in Section 6.6, which revealed that both expert and novice subjects benefited, in terms of improved judgmental accuracy, from the use of the KBS.

Another possible reason for the fact that no expert-novice differences were found in the use of explanations relates to the nature of the subjects who served as novices. It could be argued that these subjects were not complete "novices" in the sense that they had some exposure to financial analysis prior to their participation in the experiment. The results, especially in relation to the proportion of feedforward and feedback explanations used, could possibly have been significantly different had "laypersons", with no exposure at all to financial analysis, been used as novices.

7.1.2.3 Influence of The Types of Explanations

Why and How explanations are used more than the Strategic explanations that provide the overall "big picture". While this is consistent with the finding of Ye [1990] that the Why explanations were most preferred, it also shows that How explanations are used just as much as Why explanations. This suggests that the importance of the How explanations should not be
underestimated as compared to the Why explanations. This is especially important in view of the significant interaction effect between the types of explanations and user expertise. Novices used significantly more Why explanations than the Strategic explanations, while experts used significantly more How explanations as compared to the Strategic explanations. This result could be interpreted as follows --- novices use the Why explanations to gain declarative knowledge of the implications of the various input cues and the KBS conclusions, while experts use the procedural How explanations to probe and understand how the KBS performs its analysis, especially in comparison to their own analysis of the problem situation. Thus, experts and novices use different types of explanations because they have different learning objectives in such working situations. Novices want to acquire domain knowledge by learning about the implications of the various input cues used by the KBS as well as the conclusions reached by it. Experts, on the other hand, want to learn about the KBS’s problem-solving model so that they can understand how it compares to their own. They already possess an adequate understanding of the domain knowledge, so they use the How explanations, which focus more on the functioning of the KBS, rather than the Why explanations. Another interpretation is that experts use the How explanations because they don’t pay sufficient attention to "input data" as they perform at a higher level of abstraction than novices [Chi et al., 1981]. Therefore, when faced with a conclusion that they have not anticipated, they use the How explanation to understand the procedural trace back to the "input data". Novices, on the other hand, perform cognitively at the "surface" or "data" level and therefore rely less on the How explanations.

The fact that the Strategic explanation was used the least could signify that in working situations, where a specific case problem is being solved, keeping the "overall big picture" in mind is of lesser importance in terms of its learning value, as compared to instructional situations.
However, more work is needed to clarify the theoretical basis for the three types of explanations before this argument can be empirically validated in future work. Another possible reason for the result that the Strategic explanation is used the least, relates to the fact that this explanation was the same within each of the sub-analyses that the KBS performed. The spillover effects of having accessed and understood the "overall big picture" once for each of the sub-analysis, may have reduced the need for subjects to retrieve this explanation a multiple number of times.

7.1.2.4 Influence of The Level of User Agreement With The KBS

Both Ye [1990] and Lerch et al. [1990] found that the use of explanations increased the level of user agreement with KBS conclusions. This study found that there was an influence of user agreement on the number of explanations used as well. This was an inverted "U-shaped" relationship with a lower number of explanations being used when the levels of agreement were either very high or very low.

This inverted "U-shaped" phenomenon can be explained by the work of Schroder, Driver and Streufert [1967, p. 35] which utilizes the Yerkes-Dodson law [Yerkes and Dodson, 1908]. While this law states that moderate, rather than excessively high or low, levels of "motivation" would produce optimal "performance", Schroder et al. [ibid] demonstrate that by replacing a) the internal variable of "motivation" by external variables such as task complexity, and b) the external variable of "performance" by internal variables such as conceptual level or cognitive processing, the inverted "U-shaped" phenomenon is applicable to many aspects of human information processing and behaviors. Various studies of decision making have found empirical evidence of this inverted "U-shaped" phenomenon in a variety of decision environments, e.g, Miller and Gordon [1975]
contrasted the complexity of the financial reporting environment to the level of human cognitive processing in an accounting setting, and Schroeder and Benbasat [1975] contrasted the level of uncertainty in the environment to the amount of information used in inventory control and decision making. In this study, subjects used the most explanations (external variable) when they neither strongly agreed or disagreed with the conclusions provided by the KBS (internal variable). At high levels of agreement, fewer explanations are sought since there is no conflict between the user and the KBS. However, when agreement becomes too low, users tend to give up and seek fewer explanations. They may perceive that as their low level of agreement with the conclusion was too large to reconcile, and therefore simply choose to ignore that conclusion without looking at explanations.

7.1.3 Does the Use of KBS Explanations Benefit KBS Users?

The effort involved in the development of an explanation facility for a KBS can only be justified if there are significant benefits accruing to users from the use of the explanations. In situations where a KBS is used as a decision aid to make judgments under conditions of uncertainty, these benefits could be direct such as improvements in the accuracy of judgmental decision making, as well as indirect in the sense of more positive user perceptions of usefulness with or without corresponding improvements in accuracy. It was found that the use of feedback explanations had a positive effect on the accuracy of judgmental decision making. The use of feedforward explanations had a positive effect on user perceptions of the usefulness of the explanations but with no corresponding effect on the accuracy of judgmental decision making. The implications of these are discussed separately in the following sub-sections.
7.1.3.1 Effect of Explanation Use on the Accuracy of Judgmental Decision-Making

The study found that 1) the greater use of feedback explanations led to more accurate judgments being made, 2) a minimum threshold of feedback explanations had to be used before the judgments made by those using feedback explanations became significantly more accurate than the judgments made by those who had no explanations at all, 3) the use of feedforward explanations had no effect on the accuracy of judgmental decision making, 4) it did not matter, in terms of judgmental accuracy, whether feedforward and feedback explanations were provided alone or together, and 5) of the three types of explanations, only the use of the Why explanation as feedback improved the accuracy of the judgments that were made.

The result that feedback explanations are effective in improving judgmental accuracy, while feedforward explanations are not, has to be evaluated in relation to prior studies that have attempted to compare the two cognitive learning operators. A review of these studies in Chapter 2 had showed that the effectiveness of cognitive feedback had been conclusively demonstrated in a variety of contexts, while the results of the effectiveness of feedforward were less conclusive. The result of this study is therefore consistent with the literature and prior empirical work. Since feedback explanations explain the outcomes of a specific problem-solving situation, they are easier to relate to specific judgments to be made, as compared to the more generalized feedforward explanations that focus on input cues. Thus, in situations where the accuracy of judgments made with the aid of a KBS is critical, the joint provision of feedback explanations and KBS recommendations should be considered.

The significant effect of the Why explanation in feedback form is reasonable as this
explanation directly clarifies the importance, as well as the implications, of the particular outcomes that are reached by the KBS. A greater understanding of these can be expected to become directly incorporated into the subsequent judgments that are made by users. Consideration of this result in relation to the non-significant effects found for the other two feedback explanations — the How explanation which clarifies how the KBS arrived at the outcome and the Strategic explanation which clarifies the overall goal structure used by the KBS to reach the particular outcome, suggest that explanations that clarify the internal functioning of the KBS are less effective than those that clarify the relevance and importance of the outcomes reached.

Of the three prior studies that have directly attempted to compare the relative efficacies of feedforward versus feedback, the two [Steinmann, 1976; and Galbraith, 1984] that used abstract multiple-cue probability tasks had found that feedforward was just as effective as feedback in fostering the learning of judgmental accuracy. However, the results of this study are more consistent with those of the third study [Sengupta and Abdel-Hamid, 1991] which utilized an applied software project management task. This study also found that feedback was more effective than feedforward. This could suggest that unlike cognitive feedback, whose effectiveness has been demonstrated in both abstract multiple-cue probability learning tasks as well as in complex and realistic judgmental tasks, the effectiveness of feedforward in complex and realistic judgmental tasks remains to be demonstrated.

It did not matter whether feedforward and feedback explanations were provided together or in isolation. This is consistent with the earlier finding that users used just as much of the feedforward and feedback explanations in the two conditions. This finding suggests that, unlike
instructional situations, there was little interplay between feedforward and feedback explanations in working situations such as that used in this study. It had been suggested that, if feedforward is just as effective as cognitive feedback, the use of feedforward prior to the task being performed will place a ceiling on the potential improvement that can be obtained from the use of cognitive feedback subsequent to task performance. For example, Steinmann [1976] has suggested that in such a situation it would be interesting to "ascertain the point at which cognitive feedback would be required in addition to feedforward." In this study, as the use of feedforward was found to have no effect on the accuracy of judgments, the use of feedback explanations was just as effective irrespective of whether feedforward was provided or not.

7.1.3.2 Effect on User Perceptions of Usefulness

The study found that 1) user perceptions of the usefulness of the explanations improved as the proportion of feedforward explanations used increased, 2) the increased use of feedback explanations had no effect on user perceptions of usefulness, 3) providing users with both feedforward and feedback explanations led to poorer perceptions of the usefulness of the KBS than when feedforward or feedback explanations were provided alone, and 4) there was no evidence that the increased use of any of the three types of explanations had any effect on user perceptions of usefulness.

A variety of explanations can be offered for the effectiveness of feedforward explanations in fostering more positive perceptions of usefulness, especially in relation to the earlier findings that feedforward explanations are used much less than feedback explanations and that the use of feedforward explanations does not enhance the accuracy of judgmental decision making. Davis and
Olson’s [1985] postulation of the psychological value of unused information can be used to explain the positive impact of feedforward explanations on user perceptions of usefulness even though they are used to a lesser extent. According to this concept, the realization that certain information is available and accessible when needed can provide a great deal of comfort to potential users, even though a large proportion of this information is not used. Thus, KBS users may have believed that the availability of the feedforward explanations was more important than their immediate utility to making the specific judgments that were required. This is especially relevant to working situations because the user has to make constant tradeoffs between expending effort on learning and meeting the performance objectives. In such situations, although they may be choosing to use less feedforward explanations because they perceive them to be less relevant to the performance objectives, e.g., the accuracy of judgments, they may perceive their availability as being useful in relation to learning. Another possible explanation for the phenomenon is related to users’ expectations about the types of information that a KBS-type decision aid should provide. It was obvious from the subjective comments made by subjects during the use of the KBS that 1) they had not anticipated that the KBS could provide feedforward explanations, 2) that they found feedforward explanations useful, and 3) that they were not using these explanations because they felt that they had a lower value than the feedback explanations in relation to making the judgments that were required. On the other hand, the fact that feedback explanations did not affect perceptions of usefulness can be explained by the fact that these explanations conformed to users’ prior expectations about the explanations that all KBS must provide, and as a result were not perceived as providing additional value.
The finding that the use of feedforward explanations enhances user perceptions of usefulness while not improving the accuracy of judgmental decision making, can be explained by the concept of "illusion of control" [Langer, 1975; Langer and Roth, 1975]. According to this concept, the presence of certain factors, such as choice, stimulus/response familiarity, competition, and active involvement, that are ordinarily associated with improved performance in skilled situations partly governed by chance, can lead to over-optimistic beliefs about the value of such factors, as well as over-confidence about the quality of task performance. For example, it has been shown the facilitation of these factors through the provision of information [Oskamp, 1965; Paese and Sniezek, 1991] or the use of computerized decision aids, such as a what-if facility [Kotteman, Davis, and Remus, 1993], can create such an "illusion of control". In both of these circumstances, decision makers formed inflated beliefs even though in actuality neither the information provided nor the use of the decision aid led to better performance. It is postulated that by providing users with 1) an increased familiarity with stimulus and responses, 2) greater clarity about the decision choices available, and 3) greater involvement with the KBS’s functioning, the use of the feedforward explanations produced an illusion of control that led to positive user perceptions of usefulness, even though in actuality the use of feedforward explanations had no effect on the accuracy of judgmental decision making. This reasoning is also consistent with Steinmann [1976] and Galbraith’s [1984] argument that by allowing subjects to better understand and control the execution of problem solving strategies, feedforward information enables them to apply their knowledge with sufficient consistency and completeness, i.e., cognitive consistency.

The present study found that the differential use of the Why, How and Strategic explanations had no significant effects on user perceptions of usefulness. This result does not support the findings
of Ye [1990] who found variances in user perceptions of usefulness for the three types of explanations, in an experimental setting that was specifically designed to create a strong perceived need for explanations. This could mean that the applicability of Ye’s findings does not extend to complex judgmental situations.

7.1.4 Implications for a Theory of the Provision and Use of KBS Explanations

Largely because of the absence of strong psychological theories of human explanation that could guide our understanding of KBS explanation, the overall focus of this research was on theory advancement and exploration rather than theory confirmation. The discussion of the findings in the prior sections however does provide information essential for the development of a stronger theoretical foundation for the manner in which KBS should provide explanations to human users. As well, it highlights some additional requirements that have to be considered by such a theory. First, while there is value to taking a cognitive learning approach to KBS explanations, largely in the form of clarity in terms of the types of explanations that are provided, the results for user expertise indicate that other considerations have to be taken into account. For example, the use of explanations by experts could be driven by other considerations, such as investigating a competing model of expertise, rather than the desire to learn about the domain that motivates novices. As well, it has to consider differences in the learning objectives and approaches of the various user populations. Second, the context in which the KBS is used is certainly of importance. While this study distinguished between instructional and working situations, and the results pertaining to the explanation provision strategies certainly suggest that this was a critical distinction, more work needs to be done in relation to exploring other types of working situations besides that which was used in this study. As was alluded to earlier, these working situations could be classified in terms
of the relative emphasis placed on performance versus learning objectives.

In summary, this study has tackled the two central assumptions underlying the provision of KBS explanations that had not been formally tested up to now. It has demonstrated empirically that KBS explanations are used in complex judgmental situations involving the use of a KBS and that this use does benefit KBS users in terms of judgmental accuracy and perceptions of usefulness. These results reinforce the need for better and more in-depth understanding of the process of explaining, especially in relation to the factors that lead humans to seek out KBS explanations as well the various effects that result from such use.

7.2 Limitations of the Research

Considering that experimental researchers are faced with various tradeoffs, such as that between external validity and internal validity, the results of any study must be interpreted with caution based on its limitations. The selection of the laboratory research method was necessitated just as much by the desire for tight control over the various explanatory and extraneous variables, as by various practical constraints. These included: 1) most commercial KBS are proprietary and therefore difficult to secure for research purposes, and 2) their explanation facilities were not based on a clear distinction between the concepts of feedforward and feedback, as was required for this study. As well, it became clear at an early stage that the phenomenon of KBS explanations was to a great extent "context-specific" and does not lend itself easily to the artificiality of the laboratory setting. Therefore, conscious effort was made to preserve both experimental and mundane realism [Swieringa and Weick, 1982] by the use of a realistic task, obtaining the participation of working professionals, and paying particular attention to the realism of the KBS and other experimental
material that were developed. While the research questions can lend themselves to non-laboratory research methods, the requirement for a real-world organizational setting with its inherent political and social complexities, as well as the requirement for unobtrusive data collection was traded off in the interest of tighter control. While this was considered a satisfactory compromise for this study, its limitations in terms of generalizability across time, settings and populations must be recognized.

Another limitation that is recognized relates to the generalizability of the KBS and the explanations that were developed. Every computer system is unique depending on the design decisions that have to be made during its development. As detailed in Chapter 4, these were conscious design choices made to ensure that the KBS and the explanations were usable, consistent in terms of their theoretical definitions, and yet reflective of their typical implementations in practice. For example, each of the three types of explanations was presented by using the presentation method that best suited it, both as described in the academic literature and as implemented in functional KBS. Thus, the Strategic explanations were presented in the form of hierarchical trees, the How explanations as formulas or lists of inferences made, and the Why explanations as paragraphic text. Another example of such a design decision relates to the order in which the buttons for accessing explanations were presented on the screen. The button for accessing the Why explanation was consistently on the left of every screen, the button for accessing the Strategic explanation on the right, and with the button for accessing the How explanation in the middle of the other two. It was decided that no effort would be made to rotate this presentation order as it would have interfered with the realism of the experimental task by drawing attention to the fact that explanations were the central focus of this research. While the impact of such choices on subject behavior are not fully evident, the findings must be interpreted by taking these limitations
into consideration. As well, while all subjects were exposed uniformly to the same KBS in an effort to control the technological environment, the limitations in terms of external validity must also certainly be recognized. As alluded to in Chapter 4, similar concerns as to the generalizability of the diagnostic task performed by the KBS, as well as the evaluative and predictive judgments used as dependent measures, need to be kept in mind.

The sample size requirements of statistical inference had to be weighed against the limited resources available as well as the practicality of recruiting a large number of expert financial analysts. This was certainly a factor in the selection of the mixed research design that included both between-subject and within-subject factors. The relative success that met with the recruitment efforts meant that a repeated measures design and the danger of non-independent treatment effects could be avoided. The study had a power level of 70% for detecting a large main effect at the 0.05 level of alpha. As discussed in Section 5.4.1, a larger sample size would certainly have been necessary for detecting a medium or small main effect at the same level of alpha.

This study did not address the influence of using KBS explanations on the problem-solving processes of users. Rather, it focused on the decisional and perceptual end-products of these processes. While this was a function of the tradeoffs made in the selection of the research method, it promises to be a fruitful area for future explorations of KBS explanations. Some of the specific reasons why a process tracing approach was not attempted include: 1) collecting the protocols would have affected the realism of the task context that was used, 2) the complexity of the judgments and the richness of the task environment meant that the protocols would have been too lengthy and unwieldy to code "cleanly", and 3) it would have significantly increased the time that subjects took
to complete the experiment, beyond the mean of approximately two hours that was used.

Another more general limitation of the study is that while it takes a cognitive learning approach to conceptualizing the theoretical basis for the research, the experiment performed did not attempt to measure "learning" directly. Instead, it utilized the decisional surrogate of judgmental accuracy and the perceptual surrogate of user perceptions of usefulness. While this is similar to the approach taken by virtually all empirical studies under the cognitive feedback paradigm, it points to the immense difficulties inherent in the measurement of cognitive learning and in separating learning effects from other effects. This is especially relevant in a situation where resource constraints limit the development of a more complete and functional KBS. This necessitated a "one-shot, single task" format for the study instead of a "multi-trial, multi-task" longitudinal format that would have facilitated the measurement of learning.

Another limitation that must be recognized is related to the issue of novelty effects and the requirement that such studies need to capture "natural behavior". Considering that knowledge-based systems are a relatively new technology that is currently not yet extensively used in the financial industry, most subjects were being exposed to it for the first time. Therefore, despite the fact that training was used to minimize novelty effects, the behavior captured can hardly be viewed as the "natural" behavior that evolves over long periods of exposure to a technology. While this represents a general weakness that is associated with all behavioral investigations of new any technology or phenomenon, it needs to be borne in mind in the interpretation of the results.

It is also important to recognize the implications of using the consensus evaluations of the
five expert judges as the "correct" scores for computing the judgmental accuracy dependent measures. It must be kept in mind that these "correct" scores may have been different had another set of judges been used. However, since these same five judges were the "source experts" on whom the KBS was modelled, the extent to which a subject using the KBS made a good judgment indicated the degree to which the KBS helped him or her "replicate" the expertise of the five judges.

The results of the study, especially in relation to the comparative use of feedforward and feedback, must be interpreted by keeping in mind the way in which they were operationalized in this study. Unlike some other studies that operationalized feedforward as "training" provided to subjects prior to them making judgments and feedback as information provided subsequent to the making of the judgments [Sengupta and Abdel-Hamid, 1991], in this study feedforward and feedback were associated with the types of sub-analyses that the KBS performed. Therefore, they are defined with respect to each individual sub-analysis that the KBS performed and not the predictive and evaluative judgments made by each subject after using the KBS. In this study, feedforward and feedback do not only refer to differences in the timing of the provision of the explanations, but also to the following two important distinctions between them. First, feedforward explanations were generalized while feedback explanations were case-specific. Second, feedforward explanations focused on explaining the input cues and procedures necessary for each sub-analysis, while feedback explanations focused on explaining the outcomes of each sub-analysis.
7.3 Contributions of the Research

The contribution that this research makes to current knowledge of KBS explanations can be classified into two categories: theoretical and empirical. From a theoretical perspective, it advances current thinking in several ways. First, it clarifies the specific reasons as to why the explanation facility was included as an integral component of early KBS. In this regard, it also serves to provide post-hoc, theoretical justification for the need for KBS to provide explanations. Second, it provides a cognitive learning theory based feedforward-feedback model for categorizing the various types of explanations that current KBS provide, as well as for conceptualizing strategies for providing explanations that foster improved learning in working situations. Third, at a more general level, it tackles the learning that takes place when KBS-type decision support aids are used to make judgments under conditions of uncertainty. Various researchers in decision support systems have made calls for more attention to be paid to the learning phenomenon, e.g., Mackay and Elam [1992] argue that it is critical to "recognize that users undergo a significant learning experience as they work with a decision aid". Fourth, the study adds to the cumulative understanding of research based on the cognitive feedback paradigm by demonstrating the relevance and value of the cognitive learning operators to the study of KBS explanations and the financial analysis domain. For example, the result that there was little interplay between feedforward and feedback is of critical importance as the tradeoffs between them have been inadequately studied to-date and remain an active area of current research.

From an empirical perspective, the study adds to our knowledge about how to provide KBS explanations and the effects that can be expected from their use. Methodologically, it is believed to be the first study that offers empirical evidence that KBS explanations are used in "realistic"
working situations and that reveals the extent to which the various kinds of explanations are used. Considering that research into the automatic generation and technical construction of computer-based explanations has now been going on for about 15 years, empirical evidence that they are used can certainly be expected to improve the design of future KBS explanation facilities so that they are usable and of value to users. As an understanding of the specific circumstances in which KBS explanations are used is pivotal to the development of optimal designs for their provision, the results of this study add to what is already know from the Ye [1990], Lerch et al, [1990], and Lamberti and Wallace [1990] studies about the critical factors that influence the use of explanations. First, in relation to user expertise, it extends the results of the past studies by indicating that experts use just as many explanations as novices in complex judgmental situations involving the use of a KBS. Second, it clarifies the relationship between the level of user agreement and the use of explanations by revealing the specific nature of the relationship. Third, it extends Ye’s [1990] findings relating to the preferences for the three types of explanations, by revealing how these preferences influence the use of explanations, e.g., the Why explanation is used the most and the Strategic explanation the least, etc. Fourth, it clarifies the influence of the explanation provision strategies by revealing that feedback explanations are used significantly more than feedforward explanations.

Another contribution of the study is that it directly investigated another central assumption that underlies the provision of KBS explanations, i.e., that the use of explanations empowers the user by enhancing the quality of decision making. In this regard, the study followed up on Ye’s [1990, p. 164] observation that "the effect of explanations on performance is methodologically more difficult to investigate, but it is certainly more relevant". Thus, this study is believed to have been the first attempt to formally examine the value of explanations to KBS users. The finding that the
use of explanations affects both the accuracy of decision making and user perceptions of usefulness reinforces the need for KBS designers to have a more in-depth understanding of the explanation phenomenon prior to the development of extensive and costly explanation facilities.

7.4 **Directions for Future Research**

This research has taken a cognitive learning approach to understanding the use of KBS explanations and has empirically evaluated hypotheses relating both to various factors that influence the use of explanations as well as to some effects of the use of the explanations. The findings of the study especially when considered within the two-part framework for investigating the use of explanations, that was presented in Chapter 3, can serve as a basis for future research in several areas. For example, based on the knowledge gained in this study, a number of propositions can be formulated for empirical testing in future studies. These are presented below together with some specific questions that could be addressed.

**PROPOSITION 1: The use of KBS explanations leads to improved problem solving.** --- At which stage of the problem solving process are they used? Are some particular patterns of use better than others? Do the proportion of explanations used and the improvements in problem solving vary across tasks and over time?

**PROPOSITION 2: Experts use just as many explanations as novices.** --- What are the specific reasons for use? Process tracing studies could reveal if the reasons for using are the same. This study also found that experts benefit just as much as novices, in terms of improvement in accuracy resulting from the use of the KBS. Could this also be applicable to the use of explanations?
PROPOSITION 3: Feedback explanations are used approximately four times more than feedforward explanations. --- Does this finding hold in instructional situations? What is its relationship in terms of the learning versus working conflict? There is also a need to test the robustness of this finding in relation to other tasks domains and over time.

PROPOSITION 4: There is no interplay between feedforward and feedback explanations: Just as much of each is used when provided together as when each is provided alone. --- The robustness of this finding must be tested in other situations by varying the levels of the learning versus working conflict. This can be done by including as well as manipulating both performance objectives and learning objectives in experimental task instructions. Learning effects must also be measured more directly.

PROPOSITION 5: The Why and How explanations are used significantly more than the Strategic explanations. --- The preference for the Why and How explanations has now been demonstrated in two studies. Are there particular patterns in the way they are used jointly and what is the significance of these patterns? As the Why, How and Strategic explanation-types have evolved largely out practical attempts at implementing explanation facilities, a stronger cognitive and/or behavioral theoretical basis for the three types of explanations needs to be developed.

PROPOSITION 6: Experts use the How explanations more than the Strategic explanations, while novices use the Why explanations more than the Strategic explanations. --- This suggests that experts could be using explanations for very different reasons than novices. There is a need to investigate the reasons that underlie this difference in usage.
Proposition 7: The greatest number of explanations are used when users neither agree or disagree strongly with the KBS. --- In what circumstances do users strongly agree or disagree with a KBS? Is user agreement a function of particular user characteristics? This study found that user expertise was not a source of user differences in the level of agreement. The robustness of this finding must be further investigated. Other studies have shown that the use of explanations increases the level of user agreement. What is the relationship between the level of user agreement and learning?

PROPOSITION 9: The use of feedback explanations improves the accuracy of judgmental decision making. --- Does this finding hold across task domains, types of judgments, and over time? The minimum threshold of feedback explanations that have to be used to ensure improvements in accuracy could also be investigated. What is the role of "user expectations" in relation to the non-significant effect on perceptions of usefulness?

PROPOSITION 10: The use of feedforward explanations improves user perceptions of usefulness. --- In what applied situations could this be dysfunctional considering that there is no corresponding improvement in accuracy? The alternative interpretations of this result --- illusion of control and the psychological value of unused information could be investigated. As Ye [1990] also found some evidence that users perceive explanations, that they do not utilize, as being useful, this could be a phenomenon that is especially relevant to explanations.

PROPOSITION 11: The use of the Why explanation as feedback improves the accuracy of judgmental decision making. --- While this suggests that this explanation should be provided in all situations where a KBS is used to support judgmental decision making, process tracing studies need
to investigate the specific manner in which increased accuracy is achieved.

**PROPOSITION 12:** The use of explanations benefits users by affecting the accuracy of their judgments, their perceptions of usefulness, and their level of agreement with the KBS. --- The robustness of these effects should be tested in other task domains.

The framework of Chapter 3 also discusses both a wide range of other factors that could potentially influence the use of explanations, as well as other potential effects of the use of KBS explanations. This study has only investigated a subset of these factors and effects. Future research could focus on the other factors and effects that remain uninvestigated. A call can also be made to utilize a wider range of research methodologies. Significant scope remains for a field study of the use of explanations, especially one that focuses on the effects of such use.

This study could serve as a good foundation for future investigations of both the provision of KBS explanations and the learning that is associated with the use of a decision aid. The findings that explanations are utilized and are of value to users, as well as an understanding of some critical determinants and effects of the use of explanations, can be expected to be of value both to the continuing efforts at developing a stronger theoretical basis for the provision of KBS explanations as well as to the better design of explanation facilities.
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APPENDIX 1:

MATERIAL USED FOR RECRUITING SUBJECTS
Recruitment Package Used For Expert Subjects
FINANCIAL ANALYSIS EXPERT SYSTEMS STUDY

An Invitation to Professionals in Financial Decision Making

Information Sheet

We are currently studying issues related to the design of expert support systems for financial analysis. The objectives of the study are to measure their value to system users and to understand the manner in which they should be designed to be of greatest value to the users. In the initial stages of the study, such an expert system has been developed by modelling the expertise of several experts in the field. Plans are currently being made to evaluate this system in terms of facilitating financial analysis for investment and loan decision making.

Towards this end, we now would like to invite professionals in the financial industry, whose jobs involve some measure of financial statement analysis or who use the outputs of such analysis, to participate in the project. More specifically, your participation will involve the following. Initially, you will be trained in the use of the expert system. Next, your task will be to use the system to perform the financial statement analysis of a company. At the end of your analysis you will make a set of judgements regarding the financial health of the company. You will also be asked to provide evaluations of the usefulness of various aspects of the system you will use. It is expected that your participation will take between 1 and 1.5 hours and can be scheduled either at the University of British Columbia campus or at a downtown location of your choice. You will be eligible for a set of prizes to be awarded to the best performers in the task.

A direct benefit of participation will be exposure to a leading-edge, user friendly financial decision support tool that uses a "Windows-type" interface and expert financial knowledge. Any information obtained in connection with your participation that can be identified with you will remain confidential. In any reports or publications only aggregate data will be presented to preserve the anonymity of participants. There will also be no way to identify you or your company through any of your responses. Note that participation in this study is completely voluntary and, if you wish to do so, you will be free to discontinue your participation at any time and at any stage of the study.

If you have any questions now or later, please feel free to call Professor Izak Benbasat at 822-8396 and we will be happy to answer them. If you do decide to participate, please complete the attached Consent Form and Background Information Questionnaire and mail or FAX it to the address/number given on the last page. You can also confirm your participation by calling the above telephone number and leaving your name and contact number. We will then call you later to schedule your participation.
CONSENT FORM

This form is to be completed after you have read the contents of the Information Sheet that is attached. If you decide to participate, please keep a copy of this form for your records.

Agreement to Participate:

I have read and understood the contents of the Information Sheet provided and have decided to participate in the experiment.

Agreement to Confidentiality:

I understand that some of my colleagues in the financial industry may also be participating in this study. I realise that my discussion of the details of this study with them may distort the outcomes. Therefore, I agree not to discuss with other participants any aspect of the study prior to their participation.

-------------------------  ---------
Signature of Participant  Date
(Place your signature here)

Participant Name: __________________________
Telephone Number: _________________________
BACKGROUND INFORMATION QUESTIONNAIRE

(To be completed after deciding to participate in the study)

1. Name (please print): ________________________________

2. Contact Address: ________________________________
   ________________________________
   ________________________________

3. Contact Telephone Number: ________________________________

4. Education and Professional Qualifications:
   (please specify the number of years completed if in-progress)

Undergraduate ____________________ Area of Specialization ____________________

Graduate ____________________ Area of Specialization ____________________

   Professional Affiliations (eg. CFA, ACIB, CA, CGA, CMA, etc.): ______________

5. List your current job designation and the number of years you have been at this job:
   ________________________________

6. List other major job designations that you have held in the past and the number of years you
   were at each job:
   ________________________________
   ________________________________
   ________________________________
   ________________________________

7. Do you regularly perform financial statement analysis as part of your job? _______
   If yes, specify approximately how often you do so (please check one):
   Everyday: _______
   Every other day: _______
   Every week: _______
   Every fortnight: _______
   Every month: _______

   How many years of experience do you have in financial statement analysis: _______
   List the industries you specialize in, if any:
   ________________________________
   ________________________________
   ________________________________
   ________________________________
8. On the following scale, rate your knowledge of business computing:

Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar

9. List the types of financial modelling and analysis software that you have used in the past or are using now (eg. Lotus 1-2-3, FISCAL, FSAP, etc.), specify NONE otherwise:


10. On the following scale, rate your familiarity with the use of the "mouse" input device used with computer systems:

Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar

11. On the following scale, rate your familiarity with expert systems in general:

Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar

12. Have you ever used an expert system in the past? ______________
If yes, briefly describe the system and the circumstances of your use:


13. Specify your preferences in terms of the days of the week (including weekends) and the time of day (including evenings), in May or June 1992, when you will be available to participate in the experiment. Note that we will be calling you to confirm the exact day and time of your participation.


14. Will it be possible for you to be at the Henry Angus Building of the Faculty of Commerce and Business Administration at the University of British Columbia for the session?

Thank you very much for your assistance in this study.

Please return this questionnaire and the attached consent form to:

Professor Izak Benbasat
Financial Analysis Expert System Project
Faculty of Commerce and Business Administration
University of British Columbia
2053 Main Mall, Vancouver, B.C., V6T 1Z2
Phone (604) 822-8396, FAX (604) 822-8489
Recruitment Package Used For Novice Subjects
FINANCIAL ANALYSIS EXPERT SYSTEMS STUDY

An Invitation to CA Students of Financial Analysis

Information Sheet

We are currently studying issues related to the design of computer-based expert support systems for financial statement analysis. In the initial stages of the study, an expert system called FINALYZER-XS (for FINAncial anaLYZER) has been developed by modelling the knowledge and expertise of several experts in the field. Plans are currently being made to evaluate the system in terms of facilitating financial analysis for loan decision making.

Towards this end, we now would like to invite CA students who have taken or are currently taking courses related to financial statement analysis, such as SCA 100, SCA 200, SCA 300 or SCA 520, to participate in the project. More specifically, the task will involve the following. Initially, you will be trained to use FINALYZER-XS. Next, you will be asked to use the system to complete a specially designed financial analysis case about a company whose financial and other data will be provided to you. At the end of your analysis you will make a set of judgments as regards the financial health of the company. You will also be asked to provide scaled evaluations and written comments as to the usefulness of various aspects of the system. It is estimated that the your participation will take between 1 and 1.25 hours and will be scheduled at the Henry Angus Building on the University of British Columbia campus. You will be paid an honorarium of $12 for your participation and will be eligible for a set of prizes that will be awarded to the top twenty percent of all participants in the study. The exact details of these prizes will be provided at the start of the session.

A direct benefit of participation will be exposure to a user friendly financial decision support tool that uses a "Windows-type" interface and expert financial knowledge. Any information obtained in connection with the study that can be identified with you will remain confidential. In any reports or publications only aggregate data will be presented to preserve the anonymity of participants. Note that participation in this study is completely voluntary and, if you wish to do so, you will be free to discontinue participation at any time and at any stage of the study.

If you have any questions now or later, please call Professor Izak Benbasat at 822-8396 and we will be happy to answer them. If you do decide to participate, please complete the attached Consent Form and Background Information Questionnaire and mail or fax them to the address or number given on the last page. We will then call you later to schedule your participation sometime in May, June, or July 1992, at your convenience.
CONSENT FORM

This form is to be completed after you have read and understood the contents of the Information Sheet that is attached. Please note that, should you decide to participate, you will be offered a signed copy of this form to keep for your records.

Agreement to Participate:

I have read and understood the contents of the Information Sheet provided and have decided to participate in the study.

Agreement to Confidentiality:

I understand that some of my classmates and friends may also be participating in this study. I realise that my discussion of the details of this study with them may distort the results. Therefore, I agree not to discuss with any other participant any aspect of the study prior to their participation.

Signature of Participant
(Place your signature here)

Date

Participant Name: ________________________________
Telephone Number: ________________________________
BACKGROUND INFORMATION QUESTIONNAIRE

(To be completed subsequent to signing the consent form)

1. Name (please print): ________________________________

2. Contact Address: ________________________________
   ________________________________
   ________________________________

3. Contact Telephone Number: __________________________

4. Educational and Professional Qualifications: (College, University, etc.)
   (please specify the number of years completed if in-progress)
   Education: ________________________________
   ________________________________
   ________________________________
   Professional Affiliations (eg. CFA, ACIB, CA, CGA, CMA, etc.): ____________

5. List all the courses you have taken or are currently taking that dealt with aspects of ratio or financial statement analysis:
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________

6. Have you ever held any full-time, part-time, or summer job that involved computing or analyzing financial ratios? If yes, state the circumstances and the length of the period that the job was held:
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________

7. On the following scale, rate your knowledge of business computing:

   Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar
8. List the types of financial modelling and analysis software that you have used in the past or are using now (eg. Lotus 1-2-3, FISCAL, FSAP, etc.), specify NONE otherwise:

9. On the following scale, rate your familiarity with the use of the "mouse" input device used with computer systems:

Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar

10. On the following scale, rate your familiarity with expert systems in general:

Not Familiar: 1-2-3-4-5-6-7-8-9-10 : Very Familiar

11. Have you ever used an expert system in the past? 
   If yes, briefly describe the system and the circumstances of your use:

12. Specify your preferences in terms of the days of the week (including weekends) and the time of day (including evenings), in May, June, or July 1992, when you will be available to participate in the study. Note that we will be calling you to confirm the exact day and time of your participation.

13. Will it be possible for you to be at the Henry Angus Building of the Faculty of Commerce and Business Administration at the University of British Columbia for the session?

Thank you very much for your assistance in this study.

Please return this questionnaire and the attached consent form to:

Professor Izak Benbasat
Financial Analysis Expert System Study
4th Floor General Office, Henry Angus Building
Faculty of Commerce and Business Administration
University of British Columbia
2053 Main Mall, Vancouver, B.C., V6T 1Z2
Tel. 822-8396, FAX 822-8489
March 24, 1992

Mr. Harry Lee  
President  
Society for Financial Analysts  
c/o Lee, Turner & Associates, Inc.  
Suite 906  
510 Burrard  
Vancouver, B.C.,  
V6C 3A8

Dear Mr. Lee,

I am writing at the suggestion of Mr. Doug Penner, who is the President of the Edmonton chapter of the Society of Financial Analysts, to request your assistance with a research project on financial analysis expert systems. This project is being undertaken by myself and my PhD. student, Mr. Jasbir Dhaliwal. We have just completed the development of such a system, which can be viewed as an advanced research prototype of commercial systems such as FAST ADVISOR of Financial Proformas Incorporated and ANSWERS of Financial Audit Systems Incorporated.

We are currently in the process of evaluating this system in terms of a series of theoretical and practical issues that we are studying. For this purpose, we require the assistance of professionals in the financial industry, whose jobs involve some measure of financial statement analysis or who regularly use the outputs of such analysis, to participate in a study involving the use of the system. It is our hope that you can help us with this endeavour. More specifically, we would very much appreciate your assistance with the following:

1. obtaining the formal support of the Society of Financial Analysts for this project and including a copy of the attached announcement of the study in the next newsletter of the Society, and

2. assisting us in ensuring that each member of the Society receives a copy of an invitation to participate in the study.
Participation involves each individual spending about an hour using the system on a laptop personal computer which we could bring to participants’ offices. Some of the benefits to participants will be exposure to a leading edge, user friendly financial decision support tool that uses a "Windows"-type interface and expert financial knowledge. Note that I am attaching herewith, for your information, a copy of the four-page invitation package we wish to sent to each of the Society’s members. It comprises an information sheet, a consent form and a background information questionnaire.

I would be pleased to meet with you or the Society’s executive to provide more details about the project. Currently, both the Edmonton chapter of the Society for Financial Analysts and the local chapter of the Financial Executives Institute are supporting the project. I will call you sometime next week to possibly arrange a meeting and to get your views.

Lastly, I thank you in anticipation for your support. We are academic researchers, with no commercial interests or aspirations in this project, and sincerely appreciate all the support the corporate world can give us in furthering the pursuit of scientific inquiry.

Sincerely,

Izak Benbasat
Canfor Professor of Management Information Systems

IB/jd

Enclosures
APPENDIX 2:

EXPERIMENTAL TASK MATERIAL USED
(including instructions to subjects)
The following package was used by subjects in the experimental groups who received both feedforward and feedback explanations. (Groups 4 and 8)

Subjects in the other groups, who received a smaller subset of the explanations or no explanations at all, used a shorter modified version of this package. These modifications are discussed on the last page of this Appendix.
FINANCIAL ANALYSIS EXPERT SYSTEMS STUDY

Participant’s Name: ________________________________

Contents:
- General Instructions
- Tutorial on the Mouse Input Device
- A Short Note on Expert Systems
- Tutorial on the CREDIT-ADVISOR expert system
- Canacom Corporation Loan Analysis Case
- Judgment Recording Sheets (Set 1)
- Using the FINALYZER-XS expert system
- Judgment Recording Sheets (Set 2)
- Post-Study Questionnaire
- Debriefing Protocol
GENERAL INSTRUCTIONS

The objective of this study is to evaluate: 1) the use of a financial analysis expert system to complete a loan analysis case, and 2) the judgements made with the assistance of such a system. We would like you to think carefully about the financial analysis case, the system’s responses, and the judgments you make as part of your participation. Should you have any questions regarding the case, the system, the judgments or these instructions, please do not hesitate to ask the laboratory assistant for a clarification immediately.

The accuracy of the judgements you make will be evaluated using computer and statistical analysis. Individuals with scores placing in the top 20 percent of the total number of subjects participating under similar conditions will be awarded a prize of $ 50 each.

The study will proceed as follows. Initially, you are asked to complete the following two tutorials, the first relating to the use of the "mouse" input device and the second relating to the CREDIT-ADVISOR expert system which has a similar interface to the FINALYZER-XS financial analysis expert system that you will be using later. Next, you will be asked to analyze a financial analysis case relating to a Canacom Corporation and to make a set of judgments relating to it. You are welcome to use the calculator provided and to take as much time as you wish. You will then use FINALYZER-XS to complete your analysis and to make the same set of judgements again. As stated before, please take as much time as you require to do a thorough and complete analysis. The prizes will be awarded based on the quality of your judgments and not the length of time you take to complete the analysis. Finally, you will complete a short questionnaire to provide your opinions about the system you used.

Note that while you are requested to conduct your analysis under the assumption of current economic and interest rate conditions, please do not bring to bear on your analysis and judgments any fixed loan approval or other policies that may currently be used in the particular organization where you work. As we are interested specifically in your financial analysis skill and judgment, you are requested to limit your analysis to the information provided to you.
MOUSE INPUT DEVICE TUTORIAL

You will be using the computer that is on the desk in front of you. You will interact with it by means of two devices. The video display screen facing you will be used by the computer to communicate with you. For example, the screen now displays information titled "MOUSE TUTORIAL." You will use a "mouse" to communicate with the computer. It is the small white device that is placed on top of the rubber pad on the desk, and it is fast becoming a popular alternative input device to the traditional typewriter-styled keyboard.

Grasp the mouse lightly in your hand. Make sure that the side to which the cable is attached is pointing away from you. Note that your index finger comes to rest naturally on the top of two buttons that are on the mouse. These two buttons are used to give different instructions to the computer. In this study, you will only use the button that is on the left. You will do so by "clicking" once on this button with your index finger. You may now practice clicking on this button a few times.

The mouse in your hand is connected directly to an arrow that appears on the screen in front of you. Make sure you can see this arrow clearly. Move the mouse in your hand gently in any direction while pressing it softly against the rubber pad. Note that the arrow on the screen will also move in a similar direction. Practice moving the mouse in any combination of directions as you wish and note that the arrow on the screen dutifully moves in the same manner. The only limitation you have is that you must keep the mouse on the rubber pad on which it is placed.

You will communicate with the computer by moving the arrow on the screen till it is placed directly on top of a symbol or icon on the screen and clicking once with your index finger on the left button of the mouse. Usually this symbol will represent one of a set of options that the computer will be offering you. In this study, two types of symbols will be used. We call these push-buttons and radio-buttons.
Push-buttons take the form of the three buttons, labelled Vancouver, Calgary, and Edmonton, that are displayed in the box on the current screen in front of you. Move the arrow on the screen until it is placed directly over the push-button labelled "Vancouver". Click once on the left button of the mouse with your index finger. Notice that the screen has changed to another that offers three kinds of information about Vancouver --- climate, universities and sports teams. Notice also that each one of these options is preceded by a symbol similar to a small circle. These are radio-buttons.

Use the mouse to move the arrow on the screen to be directly on top of the radio-button for "Universities" and click once. This will cause the circle to become darkened in the centre to signify that it has been selected. Now move the arrow to the NEXT SCREEN push-button at the bottom of the screen and click once to see the information about Vancouver's universities. After you have read this information click again on the NEXT SCREEN push-button to move on to the next screen. This displays a question and rating scale comprising a string of radio-buttons. Read the question carefully and answer it as accurately as possible by clicking on the appropriate radio-button of the scale that reflects your evaluation. Check to make sure that the centre of this radio-button becomes darkened after you have clicked on it.

You should now be familiar with the procedure of using the mouse input device to communicate with the computer. If you feel that you are still uncomfortable with the procedure, please click on the RESTART push-button to repeat this tutorial, otherwise click on the END TUTORIAL push-button to stop. Please inform the laboratory assistant that you are finished.
A SHORT NOTE ON EXPERT SYSTEMS

Expert systems are computer systems that make the specialized knowledge and expertise of a particular domain available to decision makers. They are generally developed by closely modelling the expertise and mode of operation used by particular human experts.

Similar to human experts interacting with users of their expertise, expert systems attempt to provide users with relevant information about the inputs they use in their analysis, as well as the conclusions that they reach. For example, human medical experts commonly inform patients of the inputs they are using for their diagnosis (e.g. why they are requiring a blood test or blood pressure reading) as well as their diagnostic conclusions. Additionally, they often provide, usually at the patient’s request, explanations relating to the inputs used or the conclusions reached. Similarly, expert systems go beyond the capability of conventional computer systems to provide users with various types of explanations. These include explanations relating both to the inputs that they use and to the conclusions that they reach.

More specifically, the expert system you will be using will provide you with the following: 1) the ratios and other inputs that it will be using for each analysis, 2) the specific conclusions arising from each analysis that it performs, and 3) explanations relating to both (1) and (2). For each input used or conclusion presented, three different types of explanations will be provided. These are the WHY, HOW and STRATEGIC explanations:

1) WHY explanations justify the need for a particular input or ratio that is used or confirm the importance of a particular conclusion that is reached.

2) HOW explanations detail the manner in which a particular input or ratio is computed for use or provide a trace of the evaluations used to reach a particular conclusion.

3) STRATEGIC explanations provide information about the manner in which input information is organized (termed meta-knowledge) or the overall problem solving strategies (termed control structures) used to arrive at conclusions.
The interface of the CREDIT-ADVISOR tutorial system that you will be using now has features that are identical to the FINALYZER-XS system which you will be using later. The objective of having you use this system is to familiarize you with the types and sequences of the screens that you will encounter in the use of FINALYZER-XS. As well, it will serve as a practice session for you to become comfortable with the use of the mouse input device that you have just learned.

Assume that you are a credit officer at a local bank responsible for the evaluation of credit-card applications. The bank has received the application of a Mr. Robert Mortenstein and the key data from his application has been input into a computerised datafile. You now wish to use the CREDIT-ADVISOR expert system to evaluate the merit of the application. Please proceed as follows:

1. On the screen there is a vertical line blinking in the box next to the words "Your Name". Please type your name into this box now using the keyboard attached. When you are done, move the arrow on the screen to be over the push-button titled "Next Screen" and click once.

2. A new window will have appeared that asks you: "Do you wish to see the applicant's credit and financial information?" You have two options here as presented by the two push-buttons. Please move the arrow to the "Yes" push-button and click once on it.

3. This screen gives a summary of the applicant's credit record as stored in the computerised datafile. This is created from information provided by the applicant and that obtained from other independent sources. After you have evaluated this information for as long as you wish, click on the "Next Screen" button to go on.
4. The system will now ask you if you wish to start the credit analysis. If you click on the "No" push-button, you will be returned to the previous credit information screen. Click on the "Yes" push-button. In the window at the centre of the screen there is a list of the types of analysis that will be performed by CREDIT-ADVISOR as part of its evaluation.

5. This screen also allows you to receive three different explanations relating to each of the analysis that CREDIT-ADVISOR will be performing. To get information about any particular analysis, you must first "select" it by clicking on the radio-button preceding it. Please select one of five types of analysis, e.g. the Collateral Risk Analysis. Note that when you do this, the centre of the radio button becomes darkened. The three types of explanations available are represented by the push-buttons in the rectangular box at the bottom left of the screen. You may now click on any one of the WHY, HOW and STRATEGIC push-buttons to receive that particular explanation. When you are done reading the explanation click on "Next Screen" to return to the earlier screen.

6. Please try receiving the other two explanations now. Note that while three explanations are available to you, you have the choice of selecting only the particular ones that you wish to see. You should use this opportunity to understanding clearly what to expect for each of the WHY, HOW, and STRATEGIC explanations. Refer again to the last paragraph on page 5, relating to "A Short Note on Expert Systems", to review the definitions for each of these explanations.

7. Consider again the radio-buttons for the five types of analysis the system will perform. Note that only one of them can be "selected" at any one time. Click on one that is not "selected" now and notice that once this becomes darkened in the centre, the one that was "selected" before becomes "non-selected", i.e., its centre is no longer darkened.

8. If you now click on the "Next Screen" push-button, you will receive the recommendation of the system pertaining to the type of analysis that is "selected" at this time. Please try this for Collateral Risk Analysis.
9. The three types of explanations are also available in relation to the system's recommendations. As before, you can access them by clicking on the push-button relating to the explanation you wish to receive.

10. Please provide a rating of your agreement or disagreement with that recommendation. You do this by using the seven point scale provided below the recommendation. Please click on the radio-button corresponding to your evaluation of the conclusion. Should you click on the wrong radio-button or if you wish to change your rating, just click again on the correct radio-button.

11. Note that clicking on the "Next Screen" push-button will return you to the main screen listing the various types of analysis that CREDIT-ADVISOR performs. You can now perform another type of analysis by repeating the same procedure but by initially "selecting" a new radio-button.

12. Finally, click on to the Overall Analysis and EXIT radio-button. This also works in a similar fashion to the other types of analysis.

13. The final screen that appears offers you a choice of restarting the analysis or exiting this tutorial. You are welcome to click on the "Restart" push-button to use CREDIT-ADVISOR again. Once you feel comfortable with the use of CREDIT-ADVISOR, please click on "Exit" and tell the laboratory assistant that you are finished.
Canacom Corporation, through its chain of Computron Corner outlets, is one of North America's leading distributors of technology to the individual consumer. Close to 75 percent of its business is in the United States, with 15 percent being in Canada, and the balance is mostly in Europe. Through more than 5700 company-owned retail stores and 3000 dealer/franchise outlets, Canacom distributes a broad product line that includes microcomputers and related software; televisions, radios, audio equipment, tape recorders, and related accessories; toys, antennas, security devices, timers and calculators; electronic parts, batteries, and test equipment among other products. While microcomputers, software, and peripheral equipment were not part of the company product line five years ago and represented only 2.4 percent of sales, they represented the largest component, 34.6 percent, of total sales in 1990.

The financial statements of Canacom for 1986-90 and additional relevant qualitative information are presented below. The auditor's opinions on the financial statements have been unqualified for the past five years. To help you with your analysis, common-size financial statements and a complete set of the relevant financial ratios have been prepared for you using a computerised financial analysis package. Comparative information of Hightech Computer Corporation, a Pittsburgh-based major competitor of Canacom is provided. Additionally, the
industry composites of the electronic computing equipment manufacturing segment and the
radios, televisions, and record players retail segment have been obtained for your use. Your
superior has also suggested that you utilize the recently purchased FINALYZER-XS financial
analysis expert system to help you with the task.

You have been specifically instructed to focus on all aspects of Canacom’s valuation,
liquidity, long-term solvency, asset utilization, and profitability. As part of your report, you will
have to provide specific judgments for: 1) the exact amount of the $800 million loan requested
that you recommend as being allowable assuming that no collateral or guarantees are provided,
2) a specific estimate of the expected total net earnings of the company in the coming year, 3)
ratings of the quality of Canacom’s financial management, operating management, liquidity
position, long-term solvency position, asset utilization performance, and 4) a rating of the value
of Canacom stock as loan collateral. You will also have to provide your subjective probabilities
of the correctness of these four judgments. Please review the attached Judgement Recording
Sheets now to understand the exact format in which these judgments are to be recorded.

=== Financial Statements and Ratio Tables Attached ===
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<td>Other Assets</td>
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<td><strong>TOTAL ASSETS</strong></td>
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<td><strong>LIABILITIES AND CAPITAL</strong></td>
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<td>Store Managers Deposits</td>
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<td>Deferred Income Taxes</td>
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<td><strong>Total Revenue</strong></td>
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<td><strong>Gross Income</strong></td>
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<td>Depreciation &amp; Amortization</td>
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<td><strong>Operating Income</strong></td>
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<td>Interest Expenses***</td>
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<td>Common Shares Outstanding</td>
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<td>Stock Price</td>
<td><strong>$5.34</strong></td>
<td><strong>$10.38</strong></td>
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*Includes manufacturing payroll

** Include:

- Nonmanufacturing payroll: 206,507, 232,569, 286,494, 339,559, 395,135
- Advertising expense: 114,238, 124,138, 137,722, 160,905, 199,128
- Rental Expense: 54,606, 61,491, 73,857, 89,732, 106,970
- Foreign currency translation: 3,230, 1,722, -5,295, 3,216, 590

*** Net of interest income of: 1,234, 2,334, 7,179, 20,946, 15,139
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<td>($41,528)</td>
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<td>$7,318</td>
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<td>($152,551)</td>
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<td>Cash Flows used by Investing Activities</td>
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<td>Net Purchases of Land and Equipment</td>
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<td>($31,063)</td>
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<td>($72,675)</td>
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<td>Cash Flows from Financing Activities</td>
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<td>Net Reductions in Long-Term Debt</td>
<td>($106,669)</td>
<td>($2,165)</td>
<td>($4,022)</td>
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<td>($47,252)</td>
<td>($8,948)</td>
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<td>$42,509</td>
<td>$86,256</td>
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<td>$86,256</td>
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TABLE3.XLS
### CANACOM CORPORATION
#### Common-Size Balance Sheets
**June 30, 1986-1990**

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<td>15</td>
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<td>26</td>
<td>10</td>
<td>9</td>
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<td>100</td>
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</table>
# CANACOM CORPORATION

**Common Size Income Statements**

*June 30, 1986-1990*

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<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Other Revenue</strong></td>
<td>0.94</td>
<td>0.82</td>
<td>0.93</td>
<td>1.41</td>
<td>1.54</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>100.94</td>
<td>100.82</td>
<td>100.93</td>
<td>101.41</td>
<td>101.54</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
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<tr>
<td><strong>Cost of Goods Sold</strong>*</td>
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<td>40.73</td>
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<td><strong>Interest Expenses</strong>*</td>
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<td>1.81</td>
<td>0.91</td>
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<td>0.36</td>
<td>-1.7</td>
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<td><strong>Net Income Before Tax</strong></td>
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*Includes manufacturing payroll 2.33 2.38 2.49 2.61 2.90 n/a n/a n/a

**Include:**
- **Nonmanufacturing payroll:** 16.99 16.60 16.94 16.71 15.96 n/a n/a n/a
- **Advertising expense:** 9.40 8.97 8.14 7.92 8.04 n/a n/a n/a
- **Rental Expense:** 4.49 4.44 4.37 4.41 4.32
- **Foreign currency translation:** 0.27 0.12 -0.31 0.16 0.02 n/a n/a n/a

**Net of interest income of:** 0.10 0.17 0.42 1.03 0.61 n/a n/a n/a
## CANACOM CORPORATION
### Short-Term Liquidity Ratios
#### June 30, 1986-1990

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<td>Turnover</td>
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<td>11.60</td>
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</tr>
</thead>
<tbody>
<tr>
<td>Equity to Total Liabilities</td>
<td>0.54</td>
<td>0.68</td>
<td>1.61</td>
<td>2.03</td>
<td>2.50</td>
<td>2.61</td>
<td>0.92</td>
<td>0.46</td>
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<tr>
<td>Equity to Long-Term Liabilities</td>
<td>0.83</td>
<td>1.13</td>
<td>3.73</td>
<td>4.76</td>
<td>6.80</td>
<td>15.71</td>
<td>3.89</td>
<td>2.19</td>
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<tr>
<td>Equity to Net Property,</td>
<td>1.36</td>
<td>1.74</td>
<td>3.03</td>
<td>3.65</td>
<td>4.39</td>
<td>6.00</td>
<td>2.10</td>
<td>1.69</td>
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<tr>
<td>Plant, and Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Times Interest Earned</td>
<td>6.67</td>
<td>9.41</td>
<td>21.75</td>
<td>363.49</td>
<td>60.21</td>
<td>N/A</td>
<td>3.10</td>
<td>2.40</td>
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<tr>
<td>Earnings Coverage of</td>
<td>2.92</td>
<td>3.37</td>
<td>4.32</td>
<td>4.79</td>
<td>5.02</td>
<td>9.40</td>
<td>N/A</td>
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<tr>
<td>Fixed Charges</td>
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</tbody>
</table>
### CANACOM CORPORATION

#### Asset Utilization and Profitability

**June 30, 1986-1990**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Sales to Cash &amp; Equivalents</strong></td>
<td>32.30</td>
<td>24.60</td>
<td>11.90</td>
<td>12.10</td>
<td>8.80</td>
<td>6.90</td>
<td>13.00</td>
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<td><strong>Sales to Receivables</strong></td>
<td>76.70</td>
<td>53.80</td>
<td>40.20</td>
<td>24.30</td>
<td>23.00</td>
<td>7.20</td>
<td>5.60</td>
<td>33.00</td>
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<tr>
<td><strong>Sales to Inventories</strong></td>
<td>3.20</td>
<td>3.20</td>
<td>3.30</td>
<td>3.00</td>
<td>2.90</td>
<td>6.90</td>
<td>4.70</td>
<td>5.70</td>
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<tr>
<td><strong>Sales to Working Capital</strong></td>
<td>3.90</td>
<td>3.80</td>
<td>3.30</td>
<td>2.80</td>
<td>2.50</td>
<td>2.90</td>
<td>4.50</td>
<td>13.00</td>
</tr>
<tr>
<td><strong>Sales to Net Property, Plant, &amp; Equipment</strong></td>
<td>7.80</td>
<td>8.40</td>
<td>8.90</td>
<td>9.00</td>
<td>9.60</td>
<td>14.70</td>
<td>8.20</td>
<td>27.10</td>
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<tr>
<td><strong>Sales to Other Noncurrent Assets</strong></td>
<td>232.90</td>
<td>98.20</td>
<td>45.80</td>
<td>37.70</td>
<td>40.60</td>
<td>47.90</td>
<td>18.90</td>
<td>48.90</td>
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<tr>
<td><strong>Sales to Current Liabilities</strong></td>
<td>8.80</td>
<td>8.20</td>
<td>8.30</td>
<td>8.70</td>
<td>8.70</td>
<td>7.60</td>
<td>3.90</td>
<td>5.80</td>
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<tr>
<td><strong>Asset Turnover</strong></td>
<td>1.99</td>
<td>1.95</td>
<td>1.81</td>
<td>1.66</td>
<td>1.56</td>
<td>1.77</td>
<td>1.50</td>
<td>2.80</td>
</tr>
<tr>
<td><strong>Return on Sales (%)</strong></td>
<td>6.90</td>
<td>8.10</td>
<td>10.00</td>
<td>11.00</td>
<td>11.30</td>
<td>7.80</td>
<td>4.40</td>
<td>1.30</td>
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<tr>
<td><strong>Return on Assets (%)</strong></td>
<td>13.70</td>
<td>15.80</td>
<td>18.10</td>
<td>18.30</td>
<td>17.60</td>
<td>13.80</td>
<td>6.60</td>
<td>3.60</td>
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<tr>
<td><strong>Financial Leverage</strong></td>
<td>2.93</td>
<td>2.51</td>
<td>1.64</td>
<td>1.51</td>
<td>1.41</td>
<td>1.47</td>
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<tr>
<td><strong>Return on Equity (%)</strong></td>
<td>40.00</td>
<td>39.60</td>
<td>29.70</td>
<td>27.60</td>
<td>24.90</td>
<td>20.30</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td><strong>Return on Long-Term Liabilities &amp; Equity (%)</strong></td>
<td>16.20</td>
<td>17.90</td>
<td>19.40</td>
<td>19.20</td>
<td>18.40</td>
<td>13.80</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td><strong>Before Tax Return on Total Assets (%)</strong></td>
<td>26.50</td>
<td>29.70</td>
<td>34.20</td>
<td>34.50</td>
<td>33.30</td>
<td>26.30</td>
<td>8.60</td>
<td>4.10</td>
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<td>------</td>
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<tr>
<td>Price Earnings Ratio</td>
<td>6.28</td>
<td>9.27</td>
<td>18.18</td>
<td>12.67</td>
<td>18.73</td>
<td>27.01</td>
<td>13.55</td>
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<td>Earnings Price Ratio</td>
<td>0.16</td>
<td>0.11</td>
<td>0.06</td>
<td>0.08</td>
<td>0.05</td>
<td>0.04</td>
<td>0.07</td>
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<td>Price to Cash from Operations</td>
<td>5.44</td>
<td>8.22</td>
<td>15.35</td>
<td>10.90</td>
<td>16.28</td>
<td>20.90</td>
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<td>Price to Book Value of Equity</td>
<td>2.72</td>
<td>3.80</td>
<td>5.38</td>
<td>3.50</td>
<td>4.65</td>
<td>5.48</td>
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<tr>
<td>Dividend Yield (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
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<tr>
<td>Internal Growth Rate (%)</td>
<td>40.00</td>
<td>39.60</td>
<td>29.70</td>
<td>27.60</td>
<td>24.90</td>
<td>20.30</td>
<td>N/A</td>
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<tr>
<td>---------------------------</td>
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<td>------</td>
<td>------</td>
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<tr>
<td>Net Income</td>
<td>$83,229</td>
<td>$112,235</td>
<td>$169,602</td>
<td>$224,085</td>
<td>$278,521</td>
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<tr>
<td>Add (deduct) items not affecting cash</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Depreciation Expense</td>
<td>$17,121</td>
<td>$19,110</td>
<td>$23,228</td>
<td>$29,437</td>
<td>$38,679</td>
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<tr>
<td>Increase in Accounts Receivable</td>
<td>($5,206)</td>
<td>($9,884)</td>
<td>($16,363)</td>
<td>($41,528)</td>
<td>($23,914)</td>
<td></td>
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<tr>
<td>Increase in Inventories</td>
<td>($48,584)</td>
<td>($53,511)</td>
<td>($78,549)</td>
<td>($156,859)</td>
<td>($173,529)</td>
<td></td>
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<tr>
<td>Change in Accounts Payable</td>
<td>($15,543)</td>
<td>$24,626</td>
<td>($4,366)</td>
<td>$9,081</td>
<td>$999</td>
<td></td>
<td></td>
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<tr>
<td>Other</td>
<td>$3,772</td>
<td>($536)</td>
<td>$7,637</td>
<td>$7,318</td>
<td>$3,272</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of items not affecting cash</td>
<td>($48,440)</td>
<td>($20,195)</td>
<td>($68,413)</td>
<td>($152,551)</td>
<td>($154,493)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Net Cash Flow from Operating Activities</td>
<td>$34,789</td>
<td>$92,040</td>
<td>$101,189</td>
<td>$71,534</td>
<td>$124,028</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| Cash Flows used by Investing Activities | | | | | |
|-----------------------------------------|------|------|------|------|
| Net Purchases of Land and Equipment     | ($26,579) | ($31,063) | ($48,494) | ($67,678) | ($72,675) |

| Cash Flows from Financing Activities | | | | | |
|-------------------------------------|------|------|------|------|
| Net Reductions in Long-Term Debt     | ($106,669) | ($2,165) | ($4,022) | $16,739 | ($5,223) |
| Purchase of Treasury Stock           | ($27,396) | ($53,342) | $0 | $0 | $0 |
| Sale of Treasury Stock to Employees  | $12,954 | $15,833 | $21,077 | $29,048 | $33,654 |
| Issue of Debentures                  | $98,875 | $0 | $0 | $0 | $0 |
| Foreign Currency Adjustments          | $0 | $0 | $0 | ($10,688) | ($6,928) |
| Other                                 | $7,032 | ($7,578) | ($26,003) | ($17,825) | ($8,027) |
| Cash Provided by Financing Activities | ($15,204) | ($47,252) | ($8,948) | $17,274 | $13,476 |

| Cash at the Beginning of the Year     | $35,778 | $28,784 | $42,509 | $66,256 | $107,386 |
| Change in Cash During the Year        | ($6,994) | $13,725 | $43,747 | $21,130 | $64,829 |
| Cash at the End of the Year           | $28,784 | $42,509 | $86,256 | $87,386 | $172,215 |

| Funds Reinvestment Ratio (%)          | 7.38 | 16.99 | 13.81 | 7.19 | 9.57 |
| Funds Adequacy Ratio (5 Years: 1986-1990) | | | | | 0.56 |
JUDGEMENT RECORDING SHEETS (Set 1)

Please answer the following questions:

**Question 1**

Based on your analysis and under current economic and interest-rate conditions, rate Canacom’s current liquidity position. Please circle the correct answer.

Very Weak Position: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Position

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___%

**Question 2**

Based on your analysis and under current economic and interest-rate conditions, rate Canacom’s long-term solvency position. Please circle the correct answer.

Very Weak Position: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Position

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___%
**Question 3**

Based on your analysis and under current economic and interest-rate conditions, rate Canacom’s asset utilization performance. Please circle the correct answer.

Very Weak Performance: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Performance

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___

**Question 4**

Based on your analysis and under current economic and interest-rate conditions, rate the value of Canacom stock as loan collateral. Please circle the correct answer.

Very Low Value: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very High Value

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___
**Question 5**

Based on your analysis and under current economic and interest-rate conditions, rate the quality of Canacom's financial management. Please circle the correct answer.

Very Poor Quality: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Excellent Quality

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %

---

**Question 6**

Based on your analysis and under current economic and interest-rate conditions, rate the quality of Canacom's operating management. Please circle the correct answer.

Very Poor Quality: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Excellent Quality

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %
Question 7

Based on your analysis and under current economic and interest-rate conditions, what is your estimate of Canacom’s expected net income in the coming year?

My estimate of Canacom’s expected net income is $____ million.

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %

Question 8

Based on your analysis and under current economic and interest-rate conditions, how much of the $800 million loan being requested would you recommend as being allowable to Canacom for the purposes of streamlining operations, assuming that it is unsecured?

I estimate that $____ million should be allowable to Canacom for the purposes of streamlining operations.

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %
USING THE FINALYZER-XS EXPERT SYSTEM

The expert system you will be using is called FINALYZER-XS (for FINAncial anaLYZER). You should use it after you have analyzed yourself the financial statements and ratios that have been provided to you. Note that it was developed by modelling the expertise and knowledge of several experts in the field. It is designed to utilize financial statements that are presented to it in the form of a computerised data file. It offers you a choice as to the types of analyses you can perform, and for each analysis will inform you of the types of ratios and other inputs that it is using as part of that analysis. It also computes and presents tables of ratios identical to the ones you were provided with earlier. After applying it's expertise to these ratios, it generates a set of conclusions or recommendations relevant to the particular analysis that it is performing. It will also make available to you the WHY, HOW and STRATEGIC explanations at various stages of its processing.

The interface and format of FINALYZER-XS are identical to that of the CREDIT-ADVISOR expert system that you used earlier. As before, you will be using the mouse input device to click on either push-buttons or radio-buttons to interact with it.

To begin, please type in your name on the keyboard and use the mouse to click on the NEXT-SCREEN push-button. Note that the name of the data file where the financial statements of Canacom Corporation are stored has been filled in for you by the research assistant.
JUDGEMENT RECORDING SHEETS (Set 2)

Please answer the following questions:

Question 1

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate Canacom’s current liquidity position. Please circle the correct answer.

Very Weak Position: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Position

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %

Question 2

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate Canacom’s long-term solvency position. Please circle the correct answer.

Very Weak Position: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Position

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

___ %
Question 3

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate Canacom’s asset utilization performance. Please circle the correct answer.

Very Weak Performance: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very Strong Performance

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are **completely unsure** and 100% meaning you are **completely confident**.

___ %

Question 4

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate the value of Canacom stock as loan collateral. Please circle the correct answer.

Very Low Value: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 : Very High Value

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are **completely unsure** and 100% meaning you are **completely confident**.

___ %
**Question 5**

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate the quality of Canacom’s financial management. Please circle the correct answer.

Very Poor Quality: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 :Excellent Quality

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident. 

_____ %

**Question 6**

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, rate the quality of Canacom’s operating management. Please circle the correct answer.

Very Poor Quality: 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 :Excellent Quality

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

_____ %
Question 7

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, what is your estimate of Canacom’s expected net income in the coming year?

My estimate of Canacom’s expected net income is $______ million.

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

____% 

Question 8

Based on your analysis using FINALYZER-XS and under current economic and interest-rate conditions, how much of the $800 million loan being requested would you recommend as being allowable to Canacom for the purposes of streamlining operations, assuming that it is unsecured?

I estimate that $______ million should be allowable to Canacom for the purposes of streamlining operations.

How confident are you that this judgment is correct? Provide a number between 50% and 100%, with 50% meaning you are completely unsure and 100% meaning you are completely confident.

____%
POST STUDY QUESTIONNAIRE

(To be completed subsequent to the use of the expert system and after answering all the judgement questions)

Participant's Name: ________________________________

DIRECTIONS

Please respond to each of the following statements by placing a circle on the number that most accurately reflects your agreement or disagreement with the statement. Note that there are no right or wrong answers, rather we are interested in your opinions about aspects of the system you have just used. Consider the following example statement:

"This room is very cold today."

Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

Then, if you thought it was:
very cold, you would circle "one" on the scale above;
cold, you would circle "two" on the scale above;
cool, you would circle "three" on the scale above;
neither too warm nor too cool, you would circle "four" on the scale above;
warm, you would circle "five" on the scale above;
hot, you would circle "six" on the scale above; and
very hot, you would circle "seven" on the scale above.

1. I made good use of the explanations provided by FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

2. FINALYZER-XS fits well with the way I like to do financial statement analysis.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

3. The use of FINALYZER-XS greatly enhanced the quality of my judgements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
4. Learning to use FINALYZER-XS was easy for me.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

5. Using FINALYZER-XS enhanced my effectiveness in completing the financial analysis task.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

6. I am impressed by the level of expertise that is displayed in the explanations provided by FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

7. My interaction with FINALYZER-XS was clear and understandable.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

8. Many of the conclusions and recommendations generated by FINALYZER-XS could only have been produced by the most experienced financial analysts in industry.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

9. Using the explanations provided by FINALYZER-XS improved the quality of the analysis I performed.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

10. It was easy to get FINALYZER-XS to do what I wanted it to do.

    Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

11. The quality of financial analysis performed by FINALYZER-XS can be rated as being equivalent to that of the best human experts in the field.

    Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
12. Using the explanations provided by FINALYZER-XS was compatible with my analysis of Canacom's financial statements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

13. Using FINALYZER-XS made the financial analysis task easier to do.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

14. Using the explanations provided by FINALYZER-XS fits well with the way I like to do financial statement analysis.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

15. Using FINALYZER-XS enabled me to accomplish the financial analysis task more quickly.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

16. Using FINALYZER-XS improved the quality of the analysis I performed.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

17. Using the explanations provided by FINALYZER-XS were completely compatible with my approach to financial statement analysis.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

18. The explanations provided by FINALYZER-XS could only be provided by the most experienced financial analysts in industry.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

19. Using FINALYZER-XS was compatible with all aspects of my analysis of Canacom's financial statements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
20. Using FINALYZER-XS increased my productivity.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

21. The explanations provided by FINALYZER-XS had a significant impact on my judgements.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

22. I am impressed by the level of expertise displayed by FINALYZER-XS.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

23. FINALYZER-XS conveniently supported all the various types of analysis required to complete the judgmental decision making tasks.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

24. Overall, I found FINALYZER-XS useful in analyzing the financial statements.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

25. Using the explanations provided by FINALYZER-XS enabled me to accomplish the financial analysis more quickly.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

26. Using FINALYZER-XS gave me more control over the financial analysis task.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

27. Using the explanations provided by FINALYZER-XS made the financial analysis task easier to do.
   
   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
28. Using the explanations provided by FINALYZER-XS enhanced my effectiveness in completing the financial analysis task.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

29. Overall, I found FINALYZER-XS to be easy to use.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

30. Using the explanations provided by FINALYZER-XS increased my productivity.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

31. Using FINALYZER-XS allowed me to accomplish more analysis than would otherwise have been possible.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

32. My understanding of financial analysis has been enhanced by the use of the explanations provided by FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

33. Overall, I found the explanations provided by FINALYZER-XS useful in analyzing the financial statements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

34. It was easy for me to do the analysis using FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

35. I used the explanations provided by FINALYZER-XS adequately.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
36. The approach used by FINALYZER-XS was completely compatible with my approach to financial statement analysis.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

37. The quality of the explanations provided by FINALYZER-XS can be rated as being equivalent to that of the best human experts.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

38. Using the explanations provided by FINALYZER-XS gave me more control over the financial analysis task.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
ESSAY QUESTIONS:

In the space provided, please answer the following questions as accurately and completely as possible.

1. What are the major strengths of the FINALYZER-XS expert system?

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

2. What are the major weaknesses of the FINALYZER-XS expert system?

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

3. How would you improve the FINALYZER-XS expert system?

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
4. More specifically, what changes would you like to see in the way FINALYZER-XS provides explanations?


Thank you very much for your participation. Your contribution to this research is greatly appreciated. If you have any additional comments to add in relation to this study please use the space below.


Please return this questionnaire to the research assistant.
DEBRIEFING PROTOCOL

Thank you again for your participation. It is our hope that you enjoyed working with FINALYZER-XS in completing the case. The judgments and evaluations that you made about Canacom and the system, together with the data captured by the system of your interaction with it, will now be analyzed using a variety of computer and statistical analysis. From this we hope to learn more about the optimal manner in which expert systems for financial analysis should be designed to maximize their potential to users such as yourself. Studies such as this, that focus on users’ behaviour in using computer support tools provide valuable feedback that helps us design more user friendly and easy-to-learn human-computer interfaces.

Please take a few minutes now to consider the following information about the study. It was not revealed to you earlier at the start of the session in the interest of what is termed experimental control and validity. For a study such this to be successful it is of critical importance that you, as the user of the system, behave as objectively and as naturally as you would in a real situation requiring the use of such a system. Because it was felt that your knowing this information would distort or bias your behaviour in using FINALYZER-XS, it was decided that this information would only be revealed to you now at the end of your participation.

1. The primary focus of this study was on the explanation component of the system, i.e., the explanations that were made available by the system to you. We were specifically interested in how and when you selected any particular explanation as you conducted your analysis. From this, we hope to learn more about how expert systems should provide explanations.

2. The FINALYZER-XS system that you used is not a complete and fully functional financial analysis expert system. Developing a complete and fully functional system requires a vast amount of time and resources and is a difficult task much beyond the scope of this study. However, this study contributes to that goal by tackling some aspects of the complete problem.

If you have any comments about the above, please inform the research assistant now.
FINANCIAL ANALYSIS EXPERT SYSTEMS STUDY

"I hereby confirm that I have received the sum of $12.00 as honorarium for participating in the financial analysis expert systems study."

Name (in full): ________________________________
Social Insurance Number: _______________________
Address: ______________________________________

____________________________________________
____________________________________________
____________________________________________

Signature: ________________
Date: _____________________
NOTE:

Subjects in all groups received the foregoing package with the following exceptions:

1) The "Tutorial on the CREDIT-ADVISOR expert system" and the "Using the FINALYZER-XS expert system" were varied for the different groups. For subjects in groups 1 and 5, who received no explanations at all, these tutorials were stripped of all references to the use of explanations. For subjects in groups 2 and 6, who received only feedforward explanations, all references to feedback explanations were removed from these tutorials. Likewise, for subjects in groups 3 and 7, who received only feedback explanations, it was ensured that these tutorials made no reference to feedforward explanations.

2) The "A Short Note on Expert Systems" was different for each of the other groups. The shorter variations for the groups that did not receive both feedback and feedforward explanations are presented on the following pages.

3) Subjects in the groups that received none of the explanations used a smaller subset of the "Post-Study Questionnaire." This had all questions relating to the attributes of the explanations removed. This smaller version is also presented on the following pages.
A SHORT NOTE ON EXPERT SYSTEMS

Expert systems are computer systems that make the specialized knowledge and expertise of a particular domain available to decision makers. They are generally developed by closely modelling the expertise and mode of operation used by particular human experts.

Similar to the behaviour of human experts interacting with users of their expertise, expert systems attempt to provide users with relevant information about the inputs they use in their analysis, as well as the recommendations and conclusions that they reach as a result of it. For example, human medical experts commonly inform patients of the inputs they are using for their diagnosis (e.g., why they are requiring a blood test or blood pressure reading) as well as their diagnostic conclusions or recommendations.

The expert system you will use in this study will inform you of 1) the ratios and other input information that it is using for each type of analysis it performs, and 2) the specific conclusions arising from each analysis that it performs.
A SHORT NOTE ON EXPERT SYSTEMS

Expert systems are computer systems that make the specialized knowledge and expertise of a particular domain available to decision makers. They are generally developed by closely modelling the expertise and mode of operation used by particular human experts.

Similar to the behaviour of human experts interacting with users of their expertise, expert systems attempt to provide users with relevant information about the inputs they use in their analysis, as well as the recommendations and conclusions that they reach as a result of it. For example, human medical experts commonly inform patients of the inputs they are using for their diagnosis (e.g. why they are requiring a blood test or blood pressure reading) as well as their diagnostic conclusions or recommendations. Additionally, they often provide, usually at the patient’s request, explanations relating to the inputs used or the recommendations made. Similarly, expert systems go beyond the capability of conventional computer systems to provide users with various types of explanations. These include explanations relating to both the inputs that they use and the recommendations that they provide.

More specifically, the expert system you will be using will provide you with the following: 1) ratios and other input information that the system will be using for each type of analysis it performs, 2) the specific conclusions arising from each analysis that it performs, and 3) three kinds of explanations --- the WHY, HOW and STRATEGIC explanations.

**WHY explanations** justify the need for a particular input or ratio that is used.  
**HOW explanations** detail the manner in which a particular input or ratio is computed for use. 
**STRATEGIC explanations** provide information about the manner in which input information is organised and the overall problem solving objectives/strategies (termed meta-knowledge and control structures) that are used.
A SHORT NOTE ON EXPERT SYSTEMS

Expert systems are computer systems that make the specialized knowledge and expertise of a particular domain available to decision makers. They are generally developed by closely modelling the expertise and mode of operation used by particular human experts.

Similar to human experts interacting with users of their expertise, expert systems attempt to provide users with relevant information about the inputs they use in their analysis, as well as the conclusions that they reach. For example, human medical experts commonly inform patients of the inputs they are using for their diagnosis (e.g. why they are requiring a blood test or blood pressure reading) as well as their diagnostic conclusions. Additionally, they often provide, usually at the patient's request, explanations relating to the inputs used or the conclusions reached. Similarly, expert systems go beyond the capability of conventional computer systems to provide users with various types of explanations.

More specifically, the expert system you will be using will provide you with the following: 1) the ratios and other inputs that it will be using for each analysis, 2) the specific conclusions arising from each analysis that it performs, and 3) various explanations. For each conclusion presented, three different types of explanations will be provided. These are the WHY, HOW and STRATEGIC explanations:

1) WHY explanations justify the importance of a particular conclusion that is reached.

2) HOW explanations provide a trace of the evaluations used to reach a particular conclusion.

3) STRATEGIC explanations provide information about the overall problem solving strategies (termed meta-knowledge or control structures) used to arrive at conclusions.
<This short-version was used by subjects in the groups that received no explanations>

Reference Code: ____________

POST STUDY QUESTIONNAIRE

(To be completed subsequent to the use of the expert system and after answering all the judgement questions)

Participant’s Name: ____________________________

DIRECTIONS

Please respond to each of the following statements by placing a circle on the number that most accurately reflects your agreement or disagreement with the statement. Note that there are no right or wrong answers, rather we are interested in your opinions about aspects of the system you have just used. Consider the following example statement:

"This room is very cold today."

Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

Then, if you thought it was:
very cold, you would circle "one" on the scale above;
cold, you would circle "two" on the scale above;
cool, you would circle "three" on the scale above;
neither too warm nor too cool, you would circle "four" on the scale above;
warm, you would circle "five" on the scale above;
hot, you would circle "six" on the scale above; and
very hot, you would circle "seven" on the scale above.

1. FINALYZER-XS fits well with the way I like to do financial statement analysis.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

2. The use of FINALYZER-XS greatly enhanced the quality of my judgements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

3. Learning to use FINALYZER-XS was easy for me.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
4. Using FINALYZER-XS enhanced my effectiveness in completing the financial analysis task.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

5. My interaction with FINALYZER-XS was clear and understandable.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

6. Many of the conclusions and recommendations generated by FINALYZER-XS could only have been produced by the most experienced financial analysts in industry.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

7. It was easy to get FINALYZER-XS to do what I wanted it to do.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

8. The quality of financial analysis performed by FINALYZER-XS can be rated as being equivalent to that of the best human experts in the field.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

9. Using FINALYZER-XS made the financial analysis task easier to do.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

10. Using FINALYZER-XS enabled me to accomplish the financial analysis task more quickly.

    Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

11. Using FINALYZER-XS improved the quality of the analysis I performed.

    Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
12. Using FINALYZER-XS was compatible with all aspects of my analysis of Canacom's financial statements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

13. Using FINALYZER-XS increased my productivity.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

14. I am impressed by the level of expertise displayed by FINALYZER-XS.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

15. FINALYZER-XS conveniently supported all the various types of analysis required to complete the judgmental decision making tasks.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

16. Overall, I found FINALYZER-XS useful in analyzing the financial statements.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

17. Using FINALYZER-XS gave me more control over the financial analysis task.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

18. Overall, I found FINALYZER-XS to be easy to use.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

19. Using FINALYZER-XS allowed me to accomplish more analysis than would otherwise have been possible.

   Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree
20. It was easy for me to do the analysis using FINALYZER-XS.

Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

21. The approach used by FINALYZER-XS was completely compatible with my approach to financial statement analysis.

Strongly Agree: 1 - 2 - 3 - 4 - 5 - 6 - 7 : Strongly Disagree

ESSAY QUESTIONS:

In the space provided, please answer the following questions as accurately and completely as possible.

1. What are the major strengths of the FINALYZER-XS expert system?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. What are the major weaknesses of the FINALYZER-XS expert system?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
3. How would you improve the FINALYZER-XS expert system?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4. Would you have liked to see FINALYZER-XS provide explanations about its inputs and conclusions? If yes, what kinds of explanations would you have preferred?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Thank you very much for your participation. Your contribution to this research is greatly appreciated. If you have any additional comments to add in relation to this study please use the space below.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Please return this questionnaire to the research assistant.
APPENDIX 3:

DATA COLLECTION INSTRUCTIONS TO RESEARCH ASSISTANTS
FINANCIAL ANALYSIS EXPERT SYSTEMS STUDY

INSTRUCTIONS TO RESEARCH ASSISTANTS

STEP 0:

Set up a file with the subjects name on it and transfer the consent form and background information questionnaire into it from the CONFIRMED SUBJECTS file. Make sure you also record the experimental group to which the subject belongs [see STEP 2 below]. It will be recorded on the top of the background information questionnaire.

Ensure you have the correct set of the experimental package. These are denoted by colour depending on the group to which the subject belongs. (See the list given on the next page as part of STEP 2). Note that all the sub-components of the package will be in the sequential order in which they are to be used, as is described below.

Reboot the computer and make sure you are on the root directory.

Ensure that the data disk is labelled and placed in the B: directory.

On the side desk where the subject will do his or her analysis prior to using FINALYZER-XS, ensure that paper, pencil and the calculator are ready.

Make sure the room door is open and keep a look out for the subject.

The subject should initially be seated in front of the display screen with only the mouse and pad in front of him or her. The keyboard should be to the side in front of you. The subject will not be using the keyboard at all. You will. While, you will sit next to the subject at the keyboard to load in each of the systems, for the rest of the session you should sit unobtrusively behind the subject.

Note that all materials that the subject uses must be put into his or her file and nothing is to be discarded.
STEP 1:

Scan the consent form and background information questionnaire with the subject to confirm the following:

1) if the consent forms are signed (otherwise get subject to do it),

2) if the address and phone-# are still valid and correct,

3) if all the questions are answered (note that a) students must provide all the details of jobs held that related to financial analysis- Q6, and b) downtowners must complete Q5 to Q7 as accurately as possible)

4) note the level of expertise the subject has with using a mouse and other systems from Q8 to Q12 (this will tell you how useful they will find the mouse tutorial)

STEP 2:

Give the subject the cover page of the experimental package and get them to write their names on it. Collect it from the subject and fill in yourself the relevant reference code, which will be the group number, from the following set:

- **Group 1**: Students given no explanations  
  - GREEN
- **Group 2**: Students given only feedforward explanations  
  - PINK
- **Group 3**: Students given only feedback explanations  
  - YELLOW
- **Group 4**: Students given both explanations  
  - WHITE
- **Group 5**: Downtowners given no explanations  
  - GREEN
- **Group 6**: Downtowners given only feedforward explanations  
  - PINK
- **Group 7**: Downtowners given only feedback explanations  
  - YELLOW
- **Group 8**: Downtowners given both explanations  
  - WHITE

STEP 3:

Give them the General Instructions sheet and get them to read it. At end, emphasize to them that

1) they have a one in five chance of winning $ 50; 2) time taken is not a criterion for winning a prize, and 3) that they should limit their analysis and judgments to the information provided.
Collect the sheet back and put it in the subject’s file.

STEP 4:

Give them the mouse tutorial sheets and get them to read it. Make sure that the mouse tutorial is loaded as follows from the DOS prompt:

```
cd\jas\mtut [enter]
win mtut [enter]
```

Get them to go through the tutorial step-by-step. Those very familiar with the mouse will not do this after a few steps, let them jump ahead. At end, let all of them click on the "RESTART" button and have a few minutes to use the system for practice. Do not allow more than FIVE (5) minutes for this practice.

Finally, remind them that they will only be using the left button on the mouse, and that they should know what radio-buttons and push-buttons are and how to click on them. If anyone is still not sure about this, show it to them.

Collect the mouse tutorial back and put it in the subject’s file.

STEP 5:

Give them the "A Short Note on Expert Systems" sheet and get them to read it. At end, tell them that they can keep it on the desk in front of them and refer to it whenever they like. With the exception of groups that don’t receive any explanations (i.e., Groups 1 and 5), remind the others that they should understand the three different kinds of explanations that will be provided --- the WHY, HOW, and STRATEGIC. To those that have problems with this, if any, inform them that at the next stage, when the use the CREDIT-ADVISOR system, they will have the opportunity to view various examples of all three of these explanations.

STEP 6:

Give the subject the Credit-Advisor tutorial description. Tell them to read the first two paragraphs of it. While they are doing this, you should load in the tutorial as follows for all groups receiving some explanations (i.e., excluding Groups 1 and 5: GREEN):

```
EXIT out of WINDOWS from the last screen of the mouse tutorial 
[Should bring you back to the DOS prompt]
```  
```
cd\jas\cred [enter]
```
```
win cred_an [enter]
```
For subjects in Groups 1 and 5: No Explanations, Credit-Advisor is to be loaded in as follows:

```
EXIT out of WINDOWS from the last screen of the mouse tutorial
[Should bring you back to the DOS prompt]
cd\jas\none\cred [enter]
win cred_an [enter]
```

When subject is ready, you type in the subject’s name on the first screen, where it says "Your Name" and get the subject to make sure it is correctly spelled. Then tell the subject to use the mouse to click on NEXT-SCREEN, and to proceed with the tutorial step by step as per the instructions.

At the end, allow the subjects to click on RESTART and practice with the system a few times if they wish to do so. Limit this practice time to be not more than FIFTEEN minutes. Ask the subjects if they are now clear about and comfortable with the use of the mouse on push and radio buttons, the format of the screens, and the three types of explanations. However, do not mention the explanations to the groups (1 and 5) that are not receiving the explanations.

Collect back the tutorial description and put it in the subject’s file.

**STEP 7:**

Give the subject the Canacom Corporation Case (check to make sure all the ten tables are there) and the first set of the Judgement Recording Sheets. Point out the pen and paper plus the calculator that is available for them to use and remind them that all the ratios have been calculated for them as presented in the tables portion of the case description. Make sure they have ample table space while they analyze the case manually.

After they are finished making all the judgments, collect the set of Judgement Recording Sheets from them and check to make sure they have answered all the questions. Put this in the subject’s file immediately.

Tell subjects that there is no time limit for this step and that most subjects take between fifteen to twenty-five minutes to complete this. However, if any subject takes more than 30 minutes politely inform them of the time that has already elapsed. This will help ensure that subjects are not fatigued or rushed when the move on to using the FINALYZER-XS expert system, which is the focus of this study.

**STEP 8:**

Give subjects the "Using the FINALYZER-XS expert system" sheet. While they are reading its contents you should load in the system as follows:
EXIT out of WINDOWS from the last screen of the CREDIT-ADVISOR tutorial
[Should bring you back to the DOS prompt]
cd\jas\XXXX [enter] (see below for XXXX)
win loan_an [enter]

Note that the value of XXXX above will be as follows:

Groups 1 and 5:               NONE
Groups 2 and 6:               FORW
Groups 3 and 7:               BACK
Groups 4 and 8:               BOTH

Next, type in the subject’s last name followed by the first name without leaving a space between
them (only the first seven letters are required) in the box for log file name.

Click in the comments box and type in "GROUP X" with X being the number of the group to
which the subject belongs.

Click on the NEXT-SCREEN button and leave the screen showing the FINALYZER-XS logo.

STEP 9:

When the subject is finished reading the sheet, ask the subject if he or she has any questions.
Then give them the second set of the Judgement Recording Sheets.

Get the subject to click on the NEXT-SCREEN button and on the introduction screen that
appears you type in the subject’s name in full (last name followed by the first name).

Get the subject to click on NEXT-SCREEN again and leave them alone as they use the system.

If they ask you any questions, tell them that "we are interested in them behaving as naturally as
possible in the use of the system and that they should limit their analysis to the information that
is provided by the system and in the case description". However, if they have any trouble using
the system you should help them and make a note of it in the subject’s file.

When the subject is at the screen that lists the menu of the types of financial analysis that the
system is able to perform, tell the subject that we would like them to use FINALYZER-XS to
perform all the items on the menu, i.e., to do a complete analysis. The order they do it in
however is completely dependent on the preferences of the subject.
STEP 10:

When subject is finished with the use of FINALYZER-XS, ensure that they have completed all the judgements of the Judgement Recording Sheets. Put this in the subject’s file immediately.

Next, give the subject the Post-Study Questionnaire and get them to fill it out. Tell them to be as comprehensive as the wish in the open ended questions at the back of the questionnaire and that all comments will be much appreciated.

While the subject is doing that, you should CLOSE the last screen of FINALYZER-XS and EXIT from WINDOWS.

You should then immediately make a copy of the log file to the DATA disk that will be placed in drive B. You do this at the DOS level: COPY XXXXXXX.LOG to B:

Put the completed Post Study Questionnaire in the subject’s file. Ensure that the subject’s name is on it.

STEP 11:

Thank them for their participation and give them a copy of the DEBRIEFING PROTOCOL or verbally summarize its contents. After they have read it answer any questions that they may have, and should they want more information refer them to Izak or myself. Also, inform then that if they wish to have the results of the study sent out to them, they should inform you now.

Inform them that if they do qualify for one of the $ 50 prizes, they will be contacted by phone in July. The list of winning persons will also be posted on the MIS notice board on the 4th floor of this building at that time.

Finally, give the student subjects the $12 payment in cash and get them to fill out the "payment received" form. Ensure that their SIN number is recorded and that the form is signed.

Put the completed form in the subject’s file and thank the subject again.

STEP 12:

Take the DATA disk out of drive B: and print (on the PhD Lab’s laser printer) out the subject’s LOG file through Wordperfect. This should be done as soon as possible after the session and the print-out should also be placed in the subject’s file.
APPENDIX 4:

SCREENS OF THE MOUSE TUTORIAL
Please click once on the push-button corresponding to the city about which you wish to see more information.
Please select one of the above radio buttons and click on the NEXT SCREEN button.
Vancouver is the warmest city in Canada with very mild winters. The moderating influence of the Pacific Ocean and the shelter provided both by the looming coastal mountains and Vancouver Island ensure that temperatures virtually never fall below the freezing point. As a matter of fact, it hardly ever snows in the city. However, winters can be very wet, especially from October to November and from March to April as the moisten laden warm currents from the sea drop their load when faced by the looming coastal ranges that provide the northern backdrop to the city.
Please select one of the above radio buttons and click on the NEXT SCREEN button.
The University of Calgary is the premier post-secondary educational institution in Southern Alberta. While it is a comparatively new university, having been set up only in the late sixties, it has developed a significant reputation in the international academic arena. It is situated on a beautiful campus in the western section of the city and enjoys close links with the downtown business community.
How useful was the information provided on the last screen?

NOT USEFUL

1  2  3  4  5  6  7  VERY USEFUL

RESTART  END TUTORIAL
How useful was the information provided on the last screen?

Please CHECK a response to the question.

- VERY USEFUL
- NOT USEFUL

OK

RESTART  END TUTORIAL
APPENDIX 5:

SCREENS OF THE CREDIT-ADVISOR EXPERT SYSTEM TUTORIAL
Welcome to the CREDIT-ADVISOR EXPERT SYSTEM

Your Name: [blank]

Applicant's Name: Robert Mortenstein

Financial Information File: CA-11178
Do you wish to see the applicant's credit and financial information?

[Yes] [No]
<table>
<thead>
<tr>
<th>Name</th>
<th>Robert Mortenstein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income (gross)</td>
<td>$23,000 /yr</td>
</tr>
<tr>
<td>Occupation</td>
<td>Supervisor (City of Vancouver)</td>
</tr>
<tr>
<td>Age</td>
<td>30 Years</td>
</tr>
<tr>
<td>Marital Status</td>
<td>Married / No Children</td>
</tr>
<tr>
<td>Other Info.</td>
<td>- Chequing Account set up in 1984</td>
</tr>
<tr>
<td></td>
<td>- Living in At Present Address Since 1988</td>
</tr>
<tr>
<td></td>
<td>- Home Ownership : Renting</td>
</tr>
<tr>
<td></td>
<td>- At present job since May 1989</td>
</tr>
<tr>
<td></td>
<td>- Nature of job is full-time and continuing till April 1993</td>
</tr>
<tr>
<td>Credit History</td>
<td>No Negatives / R1 Status</td>
</tr>
</tbody>
</table>

### Assets

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car (Sundance 1989)</td>
<td>$7,000</td>
</tr>
<tr>
<td>RRSP Deposits</td>
<td>$3,000</td>
</tr>
<tr>
<td>Bank Accounts</td>
<td>$2,300</td>
</tr>
</tbody>
</table>

### Liabilities

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car Loan Remaining</td>
<td>$5,600</td>
</tr>
<tr>
<td>Credit-Card Balance Outstanding</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

### Monthly Payments

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Car Loan</td>
<td>$400</td>
</tr>
<tr>
<td>Housing (Rental)</td>
<td>$700</td>
</tr>
<tr>
<td>Credit-Card Payments</td>
<td>$150</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$1,250</td>
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</tbody>
</table>

### Credit Status

<table>
<thead>
<tr>
<th>Credit</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISA</td>
<td>$800</td>
</tr>
<tr>
<td>Canadian Tire</td>
<td>$300</td>
</tr>
</tbody>
</table>
Do you wish to start the credit analysis?

[YES] [NO]
Types of Analysis to be Performed

- Repayment Analysis
- Collateral Risk Analysis.
- Credit Status Analysis.
- Credit Limit Analysis.
- Overall Analysis and EXIT the System.

CLICK on a radio button, then on an EXPLANATION button to view explanations.
An analysis of the client's ability to repay debt is important to determine both the level of default risk, which may if necessary be covered by collateral, and the exact amount of credit to be extended.
First, the client's income and amount of fixed payments are determined. Next, a fixed payments to gross income ratio is calculated and evaluated. The current and past history of the client's income and the security of that income are also reviewed.
CREDIT ADVISOR

Overall Approval Analysis

- Repayment Analysis
- Collateral/Risk Analysis
- Credit Status Analysis
- Credit Limit Analysis

Payments to Income Ratio

Security of Income
Types of Analysis to be Performed

- Repayment Analysis
- Collateral Risk Analysis.
- Credit Status Analysis.
- Credit Limit Analysis.
- Overall Analysis and EXIT the System.

CLICK on a radio button, then on an EXPLANATION button to view explanations.
This analysis attempts to quantify the additional debt capacity that the applicant could handle. This is used to determine the maximum amount of credit that should be extended. It is important as incorrect limits can cause the loss of clients to other institutions, overextend the financial balance of marginal clients, and leave the bank in an inefficient and underexposed situation where the credit limits approved are vastly greater than those actually taken up, thus holding up other profitable loans.
This analysis sequentially considers three aspects:

1) Room for additional credit payments - This looks at the applicant's current credit payments and income to determine whether or not he/she can handle more payments. For this purpose, a gross monthly income to monthly debt payments ratio is computed and evaluated.

2) Limits on other credit - This looks at a potential client's other credit limits to come up with a suitable figure in relation to the room available for additional payments.

3) Cost-benefit of the credit limit - This determines whether the amount to be extended is large enough to benefit both the creditor and the client. For this, the level of gross yearly income is evaluated with those earning over $20,000 receiving an automatic minimum limit of $200.
CREDIT ADVISOR

CREDIT ADVISOR

5 Types of Analysis to be Performed

STRATEGIC EXPLANATION - (FFST4.txt)

Overall Approval Analysis:

- Repayment Analysis
- Collateral/Risk Analysis
- Credit Status Analysis
- Credit Limit Analysis
  - Yearly Income Level
  - Room for Additional Credit Payments
  - Limits on other credit
  - Income to Debt Payments Ratio

NEXT SCREEN
Types of Analysis to be Performed

- Repayment Analysis
- Collateral Risk Analysis.
- Credit Status Analysis.
- Credit Limit Analysis.
- Overall Analysis and EXIT the System.

CLICK on a radio button, then on an EXPLANATION button to view explanations.
CREDIT ADVISOR

RECOMMENDATIONS

Overall Recommendations.
It is recommended that the credit not be approved.

STRONGLY AGREE

Agreement With Above Conclusion?

STRONGLY DISAGREE

Explanations

Screen Control

CLICK on a conclusion, then on an EXPLANATION button to view explanation.
The applicant's strengths are having maintained a good credit status in his past credit and loan dealings and having an yearly income in excess of $20,000. However, he is currently close to being in an over-leveraged position resulting in his failure to meet the bank's repayment risk and collateral requirements. His potential as a viable future client is also marginal considering that his income is only slightly above the $20,000 limit and his job is not guaranteed beyond April 1993. Advancing the credit to him now represents an unacceptable credit risk given his present financial status.

It should be suggested to the applicant that he should reapply in the future. He should work at reducing his current debt load and possibly improving his collateral potential.
This conclusion was reached by first considering the sub-recommendations arising from the four types of analyses performed. The applicant had positive recommendations for the credit status and credit limit analyses and negative ones for repayment and collateral analyses. Having exactly two out four positive recommendations it was then necessary to judge the significance of the two negative recommendations.

Considering that the risk of default was judged as being significantly high and the weak collateral position, it was judged that these are major factors that argued against the approval of the credit. Finally, a review of this conclusion was done to evaluate the potential of the applicant as a client in the long-run. For this, the applicant's gross yearly income and his record of dealing with the bank were reviewed and judged as being inadequate.
Overall Recommendation: (Credit Not Approved)
Tradeoffs and Consideration of Potential as a Future Client (Negative)

- Repayment Recommendation (Negative)
- Collateral/Risk Recommendation (Negative)
- Credit Status Recommendation (Positive)
- Credit Limit Recommendation (Positive: Limit = 200)

Factors:
- Payments to Income Ratio (+)
- Security of Income (-)
- Marital Status (+)
- Home Ownership (-)
- Other Collateral (-)
- Car (-)
- Rent/Own (-)
- Length At Present Home (+)
- Deposits (-)
- Other Credit Facilities (+)
- Credit History (+)
- Yearly Income (+)

Additional Payments Ratio
Income to Debt Ratio
Room for Additional Credit Payments
Thank you for using the Credit Advisor Expert System.
APPENDIX 6:

SCREENS OF THE FINALYZER-XS EXPERT SYSTEM
Press the NEXT-SCREEN button to continue
User Log File Name (no extension) :- jasdhal

Comments :- Log file to test program

Make sure you specify a file name for the log file !!

Press Ctrl-ENTER to start a new paragraph.
Welcome to the FINALYzer-XS EXPERT SYSTEM

Your Name: Jasbir Dhaliwal
Company Name: Canacom Corporation
Financial Statements File: Cana.KBS
Industry Code: SIC6479
System Status

Reading Balance Sheets .................

< please wait >
System Status

Reading Income Statements............................

< please wait >
System Status

Reading Statement of Changes in Financial Position

< please wait >
Do you wish to view the financial statements?

Yes  No
## Table 1

**CANACOM CORPORATION**


<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSETS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash &amp; Equivalents</td>
<td>37,621</td>
<td>56,365</td>
<td>141,944</td>
<td>167,547</td>
<td>279,743</td>
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<tr>
<td>Accounts &amp; Notes Receivable (Net)</td>
<td>15,841</td>
<td>25,725</td>
<td>42,088</td>
<td>83,616</td>
<td>107,530</td>
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<tr>
<td>Inventories</td>
<td>381,649</td>
<td>435,160</td>
<td>513,709</td>
<td>670,568</td>
<td>844,097</td>
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<tr>
<td>Other Assets</td>
<td>12,590</td>
<td>13,809</td>
<td>11,416</td>
<td>27,000</td>
<td>31,928</td>
</tr>
<tr>
<td><strong>Total Current Assets</strong></td>
<td><strong>447,701</strong></td>
<td><strong>531,059</strong></td>
<td><strong>709,157</strong></td>
<td><strong>948,731</strong></td>
<td><strong>983,555</strong></td>
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<tr>
<td>Net Property and Equipment</td>
<td>156,670</td>
<td>165,140</td>
<td>190,429</td>
<td>224,995</td>
<td>257,620</td>
</tr>
<tr>
<td>Other Assets</td>
<td>5,218</td>
<td>14,099</td>
<td>36,909</td>
<td>53,918</td>
<td>60,990</td>
</tr>
<tr>
<td><strong>TOTAL ASSETS</strong></td>
<td><strong>609,589</strong></td>
<td><strong>710,298</strong></td>
<td><strong>936,545</strong></td>
<td><strong>1,227,644</strong></td>
<td><strong>1,581,908</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>LIABILITIES AND CAPITAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notes Payable</td>
<td>37,189</td>
<td>25,918</td>
<td>34,862</td>
<td>24,942</td>
<td>55,737</td>
</tr>
<tr>
<td>Accounts Payable</td>
<td>34,390</td>
<td>59,926</td>
<td>54,560</td>
<td>63,641</td>
<td>64,640</td>
</tr>
<tr>
<td>Accrued Expenses</td>
<td>52,343</td>
<td>59,170</td>
<td>67,206</td>
<td>92,125</td>
<td>115,054</td>
</tr>
<tr>
<td>Income Tax Payable</td>
<td>13,931</td>
<td>24,703</td>
<td>47,152</td>
<td>52,160</td>
<td>50,668</td>
</tr>
<tr>
<td><strong>Total Current Liabilities</strong></td>
<td><strong>137,053</strong></td>
<td><strong>166,717</strong></td>
<td><strong>203,780</strong></td>
<td><strong>232,868</strong></td>
<td><strong>286,099</strong></td>
</tr>
<tr>
<td>Long-Term Notes Payable</td>
<td>8,688</td>
<td>6,523</td>
<td>3,903</td>
<td>20,642</td>
<td>15,482</td>
</tr>
<tr>
<td>Debentures (Net)</td>
<td>222,045</td>
<td>222,175</td>
<td>122,428</td>
<td>122,666</td>
<td>122,938</td>
</tr>
<tr>
<td>Store Managers Deposits</td>
<td>16,718</td>
<td>14,045</td>
<td>11,972</td>
<td>9,306</td>
<td>8,490</td>
</tr>
<tr>
<td>Deferred Income Taxes</td>
<td>10,978</td>
<td>8,902</td>
<td>12,069</td>
<td>18,866</td>
<td>17,682</td>
</tr>
<tr>
<td>Other Long-Term Liabilities</td>
<td>4,954</td>
<td>6,811</td>
<td>10,530</td>
<td>10,599</td>
<td>10,345</td>
</tr>
<tr>
<td><strong>Total Liabilities</strong></td>
<td><strong>401,146</strong></td>
<td><strong>427,173</strong></td>
<td><strong>364,682</strong></td>
<td><strong>414,967</strong></td>
<td><strong>461,036</strong></td>
</tr>
<tr>
<td>Shareholders' Equity</td>
<td>208,353</td>
<td>283,125</td>
<td>571,863</td>
<td>812,677</td>
<td>1,120,872</td>
</tr>
<tr>
<td><strong>TOTAL LIABILITIES AND CAPITAL</strong></td>
<td><strong>609,589</strong></td>
<td><strong>710,298</strong></td>
<td><strong>936,545</strong></td>
<td><strong>1,227,644</strong></td>
<td><strong>1,581,908</strong></td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Net Sales</strong></td>
<td>1,215,483</td>
<td>1,384,637</td>
<td>1,691,373</td>
<td>2,032,555</td>
<td>2,475,188</td>
</tr>
<tr>
<td><strong>Other Revenue</strong></td>
<td>11,403</td>
<td>11,360</td>
<td>15,697</td>
<td>26,573</td>
<td>38,109</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>1,226,886</td>
<td>1,395,997</td>
<td>1,707,070</td>
<td>2,061,212</td>
<td>2,513,297</td>
</tr>
<tr>
<td><strong>Cost of Goods Sold</strong></td>
<td>535,549</td>
<td>594,841</td>
<td>701,777</td>
<td>826,842</td>
<td>1,008,187</td>
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<tr>
<td><strong>Gross Income</strong></td>
<td>691,337</td>
<td>801,156</td>
<td>1,005,293</td>
<td>1,234,370</td>
<td>1,505,110</td>
</tr>
<tr>
<td><strong>Selling &amp; Administrative Expenses</strong></td>
<td>484,249</td>
<td>546,325</td>
<td>645,934</td>
<td>780,378</td>
<td>930,244</td>
</tr>
<tr>
<td><strong>Depreciation &amp; Amortization</strong></td>
<td>17,121</td>
<td>19,110</td>
<td>23,288</td>
<td>29,437</td>
<td>39,679</td>
</tr>
<tr>
<td><strong>Operating Income</strong></td>
<td>189,967</td>
<td>235,721</td>
<td>336,071</td>
<td>424,555</td>
<td>536,187</td>
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<tr>
<td><strong>Interest Expenses</strong></td>
<td>28,466</td>
<td>25,063</td>
<td>15,454</td>
<td>1,166</td>
<td>8,905</td>
</tr>
<tr>
<td><strong>Net Income Before Tax</strong></td>
<td>161,501</td>
<td>210,658</td>
<td>320,617</td>
<td>423,387</td>
<td>527,282</td>
</tr>
<tr>
<td><strong>Provision for Taxes</strong></td>
<td>78,272</td>
<td>98,423</td>
<td>151,015</td>
<td>199,302</td>
<td>248,761</td>
</tr>
<tr>
<td><strong>NET INCOME AFTER TAX</strong></td>
<td>83,229</td>
<td>112,235</td>
<td>169,602</td>
<td>224,085</td>
<td>278,521</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Shares Outstanding</strong></td>
<td>106,004</td>
<td>103,644</td>
<td>102,578</td>
<td>103,395</td>
<td>104,335</td>
</tr>
<tr>
<td><strong>Net Income per Share</strong></td>
<td>$0.79</td>
<td>$1.08</td>
<td>$1.65</td>
<td>$2.17</td>
<td>$2.67</td>
</tr>
<tr>
<td><strong>Stock Price</strong></td>
<td>$5.34</td>
<td>$10.38</td>
<td>$30.00</td>
<td>$27.50</td>
<td>$50.00</td>
</tr>
</tbody>
</table>

*Includes manufacturing payroll
**Include:
- Nonmanufacturing payroll
- Advertising expense
- Rental Expense
- Foreign currency translation
***Net of interest income of:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash Flows from Operations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Income</td>
<td>$83,229</td>
<td>$112,235</td>
<td>$169,602</td>
<td>$224,085</td>
<td>$278,521</td>
</tr>
<tr>
<td><strong>Add (deduct) items not affecting cash</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation Expense</td>
<td>$17,121</td>
<td>$19,110</td>
<td>$23,228</td>
<td>$29,437</td>
<td>$38,679</td>
</tr>
<tr>
<td>Increase in Accounts Receivable</td>
<td>($5,206)</td>
<td>($9,884)</td>
<td>($16,363)</td>
<td>($41,528)</td>
<td>($23,914)</td>
</tr>
<tr>
<td>Increase in Inventories</td>
<td>($48,584)</td>
<td>($53,511)</td>
<td>($78,549)</td>
<td>($156,859)</td>
<td>($173,529)</td>
</tr>
<tr>
<td>Change in Accounts Payable</td>
<td>($15,543)</td>
<td>$24,626</td>
<td>($4,366)</td>
<td>$9,081</td>
<td>$999</td>
</tr>
<tr>
<td>Other</td>
<td>$3,772</td>
<td>($536)</td>
<td>$7,637</td>
<td>$7,318</td>
<td>$3,272</td>
</tr>
<tr>
<td>Total of items not affecting cash</td>
<td>($48,440)</td>
<td>($20,195)</td>
<td>($68,413)</td>
<td>($152,551)</td>
<td>($154,493)</td>
</tr>
<tr>
<td><strong>Net Cash Flow from Operating Activities</strong></td>
<td><strong>$34,789</strong></td>
<td><strong>$92,040</strong></td>
<td><strong>$101,189</strong></td>
<td><strong>$71,534</strong></td>
<td><strong>$124,028</strong></td>
</tr>
<tr>
<td><strong>Cash Flows used by Investing Activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Net Purchases of Land and Equipment</strong></td>
<td>($26,579)</td>
<td>($31,063)</td>
<td>($48,494)</td>
<td>($67,678)</td>
<td>($72,675)</td>
</tr>
<tr>
<td><strong>Cash Flows from Financing Activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Reductions in Long-Term Debt</td>
<td>($27,396)</td>
<td>($21,15)</td>
<td>($4,022)</td>
<td>$16,739</td>
<td>($5,223)</td>
</tr>
<tr>
<td>Issue of Debentures</td>
<td>$98,975</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Foreign Currency Adjustments</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>($10,688)</td>
<td>($6,928)</td>
</tr>
<tr>
<td>Other</td>
<td>$7,032</td>
<td>$7,578</td>
<td>$26,003</td>
<td>$17,825</td>
<td>$8,027</td>
</tr>
<tr>
<td><strong>Cash Provided by Financing Activities</strong></td>
<td>($15,204)</td>
<td>($47,252)</td>
<td>($8,948)</td>
<td>$17,274</td>
<td>$13,476</td>
</tr>
<tr>
<td><strong>Cash at the Beginning of the Year</strong></td>
<td>$35,778</td>
<td>$28,784</td>
<td>$42,503</td>
<td>$86,256</td>
<td>$107,386</td>
</tr>
<tr>
<td><strong>Change in Cash During the Year</strong></td>
<td>($6,994)</td>
<td>$13,725</td>
<td>$43,747</td>
<td>$21,130</td>
<td>$64,829</td>
</tr>
<tr>
<td><strong>Cash at the End of the Year</strong></td>
<td>$28,784</td>
<td>$42,503</td>
<td>$86,256</td>
<td>$107,386</td>
<td>$172,215</td>
</tr>
</tbody>
</table>
Do you wish to start the evaluation?

[YES] [NO]
Select Type of Financial Analysis

- Common Size - Balance Sheet Analysis
- Common Size - Income Statement Analysis
- Funds Statement Analysis
- Liquidity Analysis
- Capital Structure Analysis
- Asset Utilization and Profitability Analysis
- Market - Value Analysis
- Overall Summary and EXIT THE SYSTEM

Click on one of the above radio buttons in order to proceed to the next screen.
Common Size-Balance Sheet Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Asset Item Ratios
- Liability and Equity Item Ratios
- Comparisons to Competitor(s)
- Comparisons to Industry Composites
- Trend Evaluations
FINALYZER - XS

System Status

Computing Balance Sheet Ratios..............................

< please wait >
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash &amp; Equivalents</td>
<td>6</td>
<td>8</td>
<td>15</td>
<td>14</td>
<td>18</td>
<td>26</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Accounts &amp; Notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receivable (Net)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>24</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td>Inventories</td>
<td>63</td>
<td>61</td>
<td>55</td>
<td>55</td>
<td>53</td>
<td>26</td>
<td>28</td>
<td>53</td>
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<tr>
<td>Other Assets</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Current Assets</strong></td>
<td>74</td>
<td>75</td>
<td>77</td>
<td>78</td>
<td>80</td>
<td>84</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>Net Property and Equipment</td>
<td>25</td>
<td>23</td>
<td>20</td>
<td>18</td>
<td>16</td>
<td>12</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Other Assets</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td><strong>TOTAL ASSETS</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

| LIABILITIES AND CAPITAL      |      |      |      |      |      |                          |                             |                         |
| Current Liabilities          | 22   | 24   | 22   | 19   | 18   | 23                       | 36                          | 53                      |
| Debentures (Net)             | 38   | 32   | 14   | 11   | 8    | 0                        | 12                          | 14                      |
| Store Managers Deposits      | 3    | 2    | 1    | 1    | 1    | 1                        | 1                           | 1                       |
| Deferred Income Taxes        | 2    | 1    | 1    | 1    | 1    | 9                        | 5                           | 1                       |
| Other Long-Term Liabilities  | 1    | 1    | 1    | 2    | 1    |                          |                             |                         |
| **Total Liabilities**        | 65   | 60   | 39   | 34   | 29   | 32                       | 52                          | 68                      |
| Shareholders' Equity         | 34   | 40   | 61   | 66   | 71   | 68                       | 48                          | 32                      |
| **TOTAL LIABILITIES AND CAPITAL** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

○ The firm has a significantly low level of debt financing. While this could signify a poor ability at raising debt, it could also signal the scarcity, or failure to take advantage, of profitable investment opportunities that are available to the firm.

○ Investment in current assets has been increasing at the expense of that in fixed assets. This suggests that there could be bottlenecks in the business cash cycle and that long-term competitive ability may be eroding.
The following conclusion has been reached by the system. Please specify your level of agreement with it. To receive explanations about it, click on the radio-button that precedes the conclusion, followed by a click on the relevant explanation button. At end, please click NEXT-SCREEN to proceed.

○ There are concerns as to the size of the investment tied up in inventories and cash plus cash equivalents. These have serious implications as to the size and need for a loan for streamlining operations.

Agreement With Above Conclusion?

**STRONGLY AGREE**

1  2  3  4  5  6  7 **STRONGLY DISAGREE**

Explanations

Screen Control

PREVIOUS SCREEN  NEXT SCREEN
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Income Item Ratios
- Cost of Goods Sold to Sales Ratios
- Expense Item Ratios
- Comparisons to Competitors
- Comparisons to Industry Composites
- Trend Evaluations
System Status

Computing Income Statement Ratios......................

< please wait >
### TABLE 5

**CANACOM CORPORATION**

**Common Size Income Statements**

**June 30, 1986-1990**

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net Sales</strong></td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Other Revenue</strong></td>
<td>0.94</td>
<td>0.82</td>
<td>0.93</td>
<td>1.41</td>
<td>1.54</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>100.94</td>
<td>100.82</td>
<td>100.93</td>
<td>101.41</td>
<td>101.54</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Cost of Goods Sold</strong></td>
<td>44.06</td>
<td>42.96</td>
<td>41.49</td>
<td>40.69</td>
<td>40.73</td>
<td>51.5</td>
<td>59.7</td>
<td>66.6</td>
</tr>
<tr>
<td><strong>Gross Income</strong></td>
<td>56.88</td>
<td>57.86</td>
<td>59.44</td>
<td>60.72</td>
<td>60.81</td>
<td>48.50</td>
<td>40.30</td>
<td>33.40</td>
</tr>
<tr>
<td><strong>Selling &amp; Administrative Expenses</strong></td>
<td>39.84</td>
<td>39.46</td>
<td>38.19</td>
<td>38.40</td>
<td>37.50</td>
<td>33</td>
<td>34.5</td>
<td>29.3</td>
</tr>
<tr>
<td><strong>Depreciation &amp; Amortization</strong></td>
<td>1.41</td>
<td>1.38</td>
<td>1.38</td>
<td>1.45</td>
<td>1.56</td>
<td>2.3</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Operating Income</strong></td>
<td>15.63</td>
<td>17.02</td>
<td>19.87</td>
<td>20.87</td>
<td>21.66</td>
<td>13.20</td>
<td>5.80</td>
<td>4.10</td>
</tr>
<tr>
<td><strong>Interest Expenses</strong></td>
<td>2.34</td>
<td>1.81</td>
<td>0.91</td>
<td>0.06</td>
<td>0.36</td>
<td>-1.7</td>
<td>0.9</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Net Income Before Tax</strong></td>
<td>13.29</td>
<td>15.21</td>
<td>18.96</td>
<td>20.81</td>
<td>21.30</td>
<td>14.90</td>
<td>4.90</td>
<td>2.60</td>
</tr>
<tr>
<td><strong>Provision for Taxes</strong></td>
<td>6.44</td>
<td>7.11</td>
<td>8.93</td>
<td>9.81</td>
<td>10.05</td>
<td>7.1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Net Income After Tax</strong></td>
<td>6.85</td>
<td>8.11</td>
<td>10.03</td>
<td>11.00</td>
<td>11.25</td>
<td>7.80</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Includes manufacturing payroll
**Includes:
  Nonmanufacturing payroll | 16.99 | 16.80 | 16.94 | 16.71 | 15.96 | n/a    | n/a    | n/a    |
  Advertising expense      | 9.40  | 8.97  | 8.14  | 7.92  | 8.04  | n/a    | n/a    | n/a    |
  Rental Expense           | 4.49  | 4.44  | 4.37  | 4.41  | 4.32  | n/a    | n/a    | n/a    |
  Foreign currency translation | 0.27 | 0.12  | -0.31 | 0.16  | 0.02  | n/a    | n/a    | n/a    |
***Net of interest income of: | 0.10  | 0.17  | 0.42  | 1.03  | 0.61  | n/a    | n/a    | n/a    |
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

○ Canacom is a very profitable company with gross and net margins that are superior to its competitors and industry composites. Gross profit has been increasing due to increases in the volume of self-manufactured products and the reduction in the manufacturing costs of the computer lines.

STRONGLY AGREE  Agreement With Above Conclusion?
○ 1  ○ 2  ○ 3  ○ 4  ○ 5  ○ 6  ○ 7  STRONGLY DISAGREE

○ Considering that it deals in technological products, whose selling prices have generally been declining, Canacom’s management has successfully increased its operating revenues during the last five years.

STRONGLY AGREE  Agreement With Above Conclusion?
○ 1  ○ 2  ○ 3  ○ 4  ○ 5  ○ 6  ○ 7  STRONGLY DISAGREE
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- While costs of goods sold are stable and less than competitors and the industry averages, the company has a higher proportion of selling and administrative expenses. The former reflects the firm's above average economies of scale while the latter suggests increased competition in selling in the marketplace.

- The steady increase in manufacturing payroll suggests increased self-production at the company. This possibly reflects the company's attempts at vertical integration into manufacturing the products that it sells, especially its new computer lines.
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Evaluation of Cash Flows from Operations
- Evaluation of Cash Flows from Investing Activities
- Evaluation of Cash Flows from Financing Activities
- Funds Reinvestment Ratio
- Funds Flow Adequacy Ratio
System Status

Computing Funds Statement

< please wait >
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash Flows from Operations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Income</td>
<td>$83,229</td>
<td>$112,235</td>
<td>$169,602</td>
<td>$224,085</td>
<td>$278,521</td>
</tr>
<tr>
<td>Add (deduct) items not affecting cash</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation Expense</td>
<td>$17,121</td>
<td>$19,110</td>
<td>$23,228</td>
<td>$29,437</td>
<td>$38,679</td>
</tr>
<tr>
<td>Increase in Accounts Receivable</td>
<td>($5,206)</td>
<td>($3,884)</td>
<td>($16,363)</td>
<td>($41,528)</td>
<td>($23,914)</td>
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<tr>
<td>Increase in Inventories</td>
<td>($48,584)</td>
<td>($53,511)</td>
<td>($78,549)</td>
<td>($156,859)</td>
<td>($173,529)</td>
</tr>
<tr>
<td>Change in Accounts Payable</td>
<td>($15,543)</td>
<td>$24,626</td>
<td>($4,366)</td>
<td>$9,081</td>
<td>$999</td>
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<tr>
<td>Other</td>
<td>$3,772</td>
<td>($536)</td>
<td>$7,637</td>
<td>$7,318</td>
<td>$3,272</td>
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<tr>
<td>Total of items not affecting cash</td>
<td>($48,440)</td>
<td>($20,195)</td>
<td>($68,413)</td>
<td>($152,551)</td>
<td>($154,493)</td>
</tr>
<tr>
<td><strong>Net Cash Flow from Operating Activities</strong></td>
<td><strong>$34,709</strong></td>
<td><strong>$92,040</strong></td>
<td><strong>$101,109</strong></td>
<td><strong>$71,534</strong></td>
<td><strong>$124,028</strong></td>
</tr>
<tr>
<td><strong>Cash Flows used by Investing Activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Purchases of Land and Equipment</td>
<td>($26,579)</td>
<td>($31,063)</td>
<td>($48,494)</td>
<td>($67,678)</td>
<td>($72,675)</td>
</tr>
<tr>
<td><strong>Cash Flows from Financing Activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Reductions in Long-Term Debt</td>
<td>($106,669)</td>
<td>($2,165)</td>
<td>($4,022)</td>
<td>$16,739</td>
<td>($5,223)</td>
</tr>
<tr>
<td>Purchase of Treasury Stock</td>
<td>($27,396)</td>
<td>($53,342)</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Sale of Treasury Stock to Employees</td>
<td>$12,954</td>
<td>$15,833</td>
<td>$21,077</td>
<td>$29,048</td>
<td>$33,654</td>
</tr>
<tr>
<td>Issue of Debentures</td>
<td>$98,875</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Foreign Currency Adjustments</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>($10,688)</td>
<td>($6,926)</td>
</tr>
<tr>
<td>Other</td>
<td>$7,032</td>
<td>($7,578)</td>
<td>($26,003)</td>
<td>($17,825)</td>
<td>($8,027)</td>
</tr>
<tr>
<td><strong>Cash Provided by Financing Activities</strong></td>
<td>($15,204)</td>
<td>($47,252)</td>
<td>($8,948)</td>
<td><strong>$17,274</strong></td>
<td><strong>$13,476</strong></td>
</tr>
<tr>
<td>Cash at the Beginning of the Year</td>
<td>$35,778</td>
<td>$28,784</td>
<td>$42,509</td>
<td>$86,256</td>
<td>$107,386</td>
</tr>
<tr>
<td>Change in Cash During the Year</td>
<td>($6,994)</td>
<td><strong>$13,725</strong></td>
<td><strong>$43,747</strong></td>
<td><strong>$21,130</strong></td>
<td><strong>$64,829</strong></td>
</tr>
<tr>
<td>Cash at the End of the Year</td>
<td>$28,784</td>
<td>$42,509</td>
<td>$86,256</td>
<td>$107,386</td>
<td><strong>$172,215</strong></td>
</tr>
<tr>
<td>Funds Reinvestment Ratio (%)</td>
<td>7.38</td>
<td>16.99</td>
<td>13.81</td>
<td>7.19</td>
<td>9.57</td>
</tr>
<tr>
<td>Funds Adequacy Ratio (5 Year: 1986-1990)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.56</td>
</tr>
</tbody>
</table>

**TABLE 10**
CANACOM CORPORATION
Statement of Changes in Financial Position (in thousands)
Years Ending June 30, 1986-1990
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- The company manages its cash inflows and outflows well and should have few problems in obtaining financing.
  - STRONGLY AGREE
  - Agreement With Above Conclusion?
  - 1 2 3 4 5 6 7
  - STRONGLY DISAGREE

- The funds flow adequacy of the company is low. It is not generating sufficient cash from operations to cover capital expenditures and net investments in inventories, etc. There is a need to secure additional financing for operations.
  - STRONGLY AGREE
  - Agreement With Above Conclusion?
  - 1 2 3 4 5 6 7
  - STRONGLY DISAGREE
The following conclusion has been reached by the system. Please specify your level of agreement with it. To receive explanations about it, please click on the radio-button that precedes it, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

○ The firm is reinvesting adequately to maintain its operating capacity. However, there is a concern as to whether it is investing sufficiently to take advantage of its growth opportunities.

Agreement With Above Conclusion?

STRONGLY AGREE  ○  1  ○  2  ○  3  ○  4  ○  5  ○  6  ○  7  STRONGLY DISAGREE
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Current Ratio
- Acid-Test Ratio
- Accounts Receivable Turnover
- Inventory Turnover
- Day Sales in Receivables
- Oper. Cash Flow to Total Curr. Liab.
- Days to Sell Inventory
- Conversion Period [days]
- % Cash to Current Assets
- % Cash to Current Liabilities
- Working Capital [million $]
- Liquidity Index
System Status

Computing Liquidity Ratios

< please wait >
## CANACOM CORPORATION
### Short-Term Liquidity Ratios
#### June 30, 1986-1990

<table>
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<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Ratio</strong></td>
<td>3.25</td>
<td>3.15</td>
<td>3.48</td>
<td>4.07</td>
<td>4.42</td>
<td>3.64</td>
<td>2.70</td>
<td>1.40</td>
</tr>
<tr>
<td><strong>Acid-Test Ratio</strong></td>
<td>0.39</td>
<td>0.49</td>
<td>0.90</td>
<td>1.08</td>
<td>1.35</td>
<td>2.17</td>
<td>1.10</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Accounts Receivable Turnover</strong></td>
<td>76.73</td>
<td>53.82</td>
<td>40.19</td>
<td>24.31</td>
<td>23.02</td>
<td>7.20</td>
<td>5.60</td>
<td>45.50</td>
</tr>
<tr>
<td><strong>Inventory Turnover</strong></td>
<td>1.40</td>
<td>1.37</td>
<td>1.37</td>
<td>1.23</td>
<td>1.19</td>
<td>3.55</td>
<td>3.10</td>
<td>3.60</td>
</tr>
<tr>
<td><strong>Day Sales in Receivables</strong></td>
<td>4.80</td>
<td>6.80</td>
<td>9.10</td>
<td>15.00</td>
<td>15.90</td>
<td>50.70</td>
<td>65.20</td>
<td>8.00</td>
</tr>
<tr>
<td><strong>Days to Sell Inventory</strong></td>
<td>260.70</td>
<td>266.40</td>
<td>266.40</td>
<td>296.70</td>
<td>306.70</td>
<td>102.80</td>
<td>117.70</td>
<td>101.40</td>
</tr>
<tr>
<td><strong>Conversion Period (days)</strong></td>
<td>265.50</td>
<td>273.20</td>
<td>275.50</td>
<td>311.70</td>
<td>322.60</td>
<td>153.50</td>
<td>182.90</td>
<td>103.40</td>
</tr>
<tr>
<td><strong>%Cash to Current Assets</strong></td>
<td>8.40</td>
<td>10.61</td>
<td>20.02</td>
<td>17.66</td>
<td>22.14</td>
<td>30.55</td>
<td>14.80</td>
<td>11.60</td>
</tr>
<tr>
<td><strong>%Cash to Current Liabilities</strong></td>
<td>27.29</td>
<td>33.41</td>
<td>69.68</td>
<td>71.95</td>
<td>97.78</td>
<td>1112.57</td>
<td>29.60</td>
<td>16.50</td>
</tr>
<tr>
<td><strong>Working Capital (millions$)</strong></td>
<td>309.95</td>
<td>362.34</td>
<td>505.43</td>
<td>715.86</td>
<td>977.2</td>
<td>340.21</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Liquidity Index</strong></td>
<td>233.10</td>
<td>230.20</td>
<td>203.40</td>
<td>228.10</td>
<td>222.50</td>
<td>51.1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Operating Cash Flow to Total Current Liabilities</strong></td>
<td>0.73</td>
<td>0.78</td>
<td>0.95</td>
<td>1.09</td>
<td>1.11</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

1. Canacom is in a very favourable working capital position indicating little risk in the short term of financial disaster. It would be an optimal client for a short-term loan.
   - Agreement With Above Conclusion?
     - STRONGLY AGREE
     - STRONGLY DISAGREE

2. There is an increasing trend toward having a high proportion of sales on credit. While the proportion has tripled in the last five years, it still remains within a range well below industry levels.
   - Agreement With Above Conclusion?
     - STRONGLY AGREE
     - STRONGLY DISAGREE
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- **Inventory is very unfavourable in comparison with major competitors and industry composites.** The decreasing trend also suggests the need to extend tighter control over inventory management.
  
  ![Agreement Options]

- **The cash and cash equivalents position of Canacom has been improving from a below than the industry-average level to a better than the industry-average level.** This has to be carefully monitored as a continuing trend could lead to a sub-optimal situation.
  
  ![Agreement Options]
Capital Structure Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Equity to Total Debt
- Equity to Long-term Debt
- Equity to Net Property, Plant and Equipment
- Times Interest Earned
- Earnings Coverage of Fixed Charges
FINALYZER - XS

System Status

Computing Capital Structure Ratios

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<td>Equity to Total Liabilities</td>
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<td>2.50</td>
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<td>0.83</td>
<td>1.13</td>
<td>3.73</td>
<td>4.76</td>
<td>6.80</td>
<td>15.71</td>
<td>3.89</td>
<td>2.19</td>
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<td>Equity to Net Property, Plant, and Equipment</td>
<td>1.36</td>
<td>1.74</td>
<td>3.03</td>
<td>3.65</td>
<td>4.39</td>
<td>6.00</td>
<td>2.10</td>
<td>1.69</td>
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<td>Times Interest Earned</td>
<td>6.67</td>
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<td>60.21</td>
<td>N/A</td>
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<td>Earnings Coverage of Fixed Charges</td>
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<td>3.37</td>
<td>4.32</td>
<td>4.79</td>
<td>5.02</td>
<td>9.40</td>
<td>N/A</td>
<td>N/A</td>
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The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

O The company has been choosing to finance its operations through equity rather than debt in the last five years. This has moved it from a below than average solvent position to an above average solvent position. It now has great capacity to safely take on significant new debt.

Agreement With Above Conclusion?

STRONGLY
AGREE

STRONGLY
DISAGREE

O There is a concern as to Canacom's ability to grow. It is not optimizing its ability to obtain financing to fully realize the growth potential of the high technology industry. The significantly high level of equity suggests that conservative capital structure management may be holding back Canacom's strategic potential.

Agreement With Above Conclusion?

STRONGLY
AGREE

STRONGLY
DISAGREE
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- Canacom may not be maintaining enough investment to remain competitive. Its current leverage ratios are more similar to those found in more mature industries than the rapidly expanding high-technology industry.

- The company is earning sufficient funds to cover all fixed charges such as interest, lease and rent payments. This position has been improving steadily suggesting little danger of the company defaulting on its fixed obligations. However, having much too large a safety cushion for these charges could possibly suggest that the company is under-leveraged.
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Sales to Cash and Equivalents
- Sales to Receivables
- Sales to Inventories
- Sales to Working Capital
- Sales to Net Prop., Plant and Equip.
- Sales to Other Noncurrent Assets
- Return on Long-Term Liab. and Equity
- Sales to Current Liabilities
- Asset Turnover
- Return on Sales (%)
- Return on Assets [%]
- Financial Leverage
- Return on Equity [%]
- Before Tax Return on Total Assets
System Status

Computing Asset Utilization and Profitability Ratios...

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<td>Sales to Cash &amp; Equivalents</td>
<td>32.30</td>
<td>24.60</td>
<td>11.90</td>
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<td>7.20</td>
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<td>2.90</td>
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<td>Sales to Net Property, Plant, &amp; Equipment</td>
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<td>8.90</td>
<td>9.00</td>
<td>9.60</td>
<td>14.70</td>
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<td>Sales to Other Noncurrent Assets</td>
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<td>45.80</td>
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<td>40.60</td>
<td>47.90</td>
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<td>Sales to Current Liabilities</td>
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<td>8.70</td>
<td>7.60</td>
<td>3.90</td>
<td>5.80</td>
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<td>Asset Turnover</td>
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<td>1.95</td>
<td>1.81</td>
<td>1.66</td>
<td>1.56</td>
<td>1.77</td>
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<tr>
<td>Return on Sales (%)</td>
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<td>10.00</td>
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<td>11.30</td>
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<tr>
<td>Return on Assets (%)</td>
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<td>15.80</td>
<td>18.10</td>
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<td>17.60</td>
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<td>Return on Equity (%)</td>
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<td>29.70</td>
<td>27.60</td>
<td>24.90</td>
<td>20.30</td>
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<td>Return on Long-Term Liabilities &amp; Equity (%)</td>
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<td>19.40</td>
<td>19.20</td>
<td>18.40</td>
<td>13.80</td>
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<tr>
<td>Before Tax Return on Total Assets (%)</td>
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<td>34.20</td>
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<td>33.30</td>
<td>26.30</td>
<td>8.60</td>
<td>4.10</td>
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The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- Canacom's management is following a policy of accepting a lower asset turnover for higher gross margins. This is paying off currently in the form of better-than-industry return on assets as the increase in the return on sales more than offsets the expense of the lower asset utilization rates. However, there is a concern about Canacom's ability to continue this policy in the future, especially in the face of the increased competition of the electrical and electronic products marketplace.

- Assets utilization ratios have been on a declining trend. Management should consider seriously the trade-offs between the benefit of holding back each particular class of assets and the cost of tying up funds in that class of assets. The declining trend suggests that management is having a low level of success in coping with the changing business environment.
The following conclusion has been reached by the system. Please specify your level of agreement with it. To receive explanations about it, please click on the radio-button that precedes it, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- The return on equity of the firm, while still at a reasonable level for the industry is diminishing steadily. There are reduced expectations of superior-to-industry future earnings.

Agreement With Above Conclusion?

| STRONGLY AGREE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | STRONGLY DISAGREE |

Explanations

Screen Control

PREVIOUS SCREEN  
NEXT SCREEN
Finalizer - XS

Market Value Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Price Earnings Ratio
- Earnings Price Ratio
- Price to Cash From Operations
- Price to Book Value of Equity
- Dividend Yield [%]
- Internal Growth Rate [%]

Screen Control

[WHY] [HOW] [STRATEGIC]

START ANALYSIS
Computing Market Value Ratios..............................

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<td>Hightech</td>
<td>S&amp;P500</td>
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<td>9.27</td>
<td>18.18</td>
<td>12.67</td>
<td>18.73</td>
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<td>0.11</td>
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<td>0.05</td>
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<td>Price to Cash from</td>
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<td>10.90</td>
<td>16.28</td>
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<td>Price to Book Value of</td>
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<tr>
<td>Dividend Yield (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
</tr>
<tr>
<td>Internal Growth Rate (%)</td>
<td>40.00</td>
<td>39.60</td>
<td>29.70</td>
<td>27.60</td>
<td>24.90</td>
<td>20.30</td>
<td>N/A</td>
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</tbody>
</table>
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- Considering its fundamentals, the stock price of Canacom is high and slightly overvalued. This suggests that it could be a good time for management to raise equity capital. As stock prices are expected to level off in the medium-term, it is not recommended that convertible stock be accepted for the purposes of securing a loan.

  - [Radio-button choices: STRONGLY AGREE, AGREE, STRONGLY DISAGREE]

- The company's growth rate has peaked and the over-optimistic stock price can be expected to fall more in line with the market in the future. It signifies urgent management action is needed to sustain the rapid growth of the last five years.

  - [Radio-button choices: STRONGLY AGREE, AGREE, STRONGLY DISAGREE]
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

- The consistent increase in the price-earnings ratio over the last five years is an indication that from the market's perspective the company is doing significantly well.
  - Agree
    - Agree With Above Conclusion?
    - STRONGLY AGREE
      - 1
      - 2
      - 3
      - 4
      - 5
      - 6
      - 7
    - STRONGLY DISAGREE

- Management's policy of not paying dividends may change considering the current high level of equity financing and the large amount of cash being held. This must be clarified as it can affect the firm's need for a loan.
  - Agree
    - Agree With Above Conclusion?
    - STRONGLY AGREE
      - 1
      - 2
      - 3
      - 4
      - 5
      - 6
      - 7
    - STRONGLY DISAGREE

Explanations

Screen Control
A. POSITIVE FACTORS
1. Liquidity position is strong and improving. Little risk of default.
2. Market value is high considering the fundamentals.
3. Capital structure is highly equity based with scope to take on debt.
4. Profitability is above-average in industry and remains strong.
5. Operating revenues have been increasing steadily in the last five years.
6. Cash inflows and outflows have been managed well.
7. Reinvestment of funds is adequate with no dividend payout.
8. Has successfully used a policy of accepting lower asset turnover for higher margins.
9. Price to earnings value is strong and improving consistently.

B. NEGATIVE FACTORS
1. Funds flow adequacy to cover capital expenditures and inventory purchases is low.
2. Too much investment is tied up in cash and its equivalents.
3. Conservative capital management may be holding up strategic potential.
4. May not be reinvesting adequately to maintain competitive position.
5. Selling and administrative costs are increasing, suggesting increased competition.
6. Asset utilization and return on equity have been declining consistently.
7. Growth rate has peaked and stock price will decline in the medium term.
8. Inventory and receivables management has been weak and worsening.
9. Too little debt in the capital structure is adversely affecting return on equity.
Thank you for using FINALYZER - XS.
Please click on the NEXT-SCREEN button.
APPENDIX 7:
EXAMPLES OF THE FEEDFORWARD AND FEEDBACK EXPLANATIONS
PROVIDED BY FINALYZER-XS
Three complete groups of examples are provided in this Appendix, one each for three different types of financial analysis that FINALYZER-XS performed. Each group is comprised of two different sets: 1) a set of the Why, How, and Strategic explanations for feedforward; and 2) a set of the Why, How, and Strategic explanations for feedback. As a whole, FINALYZER-XS offered 53 sets of feedforward explanations and 25 sets of feedback explanations. The examples provided on the following pages are organized in the following sequential order:

1. Asset Utilization & Profitability Analysis: Feedforward Screen
3. Asset Utilization & Profitability Analysis: Feedforward How Explanation
4. Asset Utilization & Profitability Analysis: Feedforward Strategic Explanation
5. Asset Utilization & Profitability Analysis: Feedback Screen
8. Asset Utilization & Profitability Analysis: Feedback Strategic Explanation

1. Capital Structure Analysis: Feedforward Screen
2. Capital Structure Analysis: Feedforward Why Explanation
4. Capital Structure Analysis: Feedforward Strategic Explanation
5. Capital Structure Analysis: Feedback Screen

1. Liquidity Analysis: Feedforward Screen
2. Liquidity Analysis: Feedforward Why Explanation
3. Liquidity Analysis: Feedforward How Explanation
4. Liquidity Analysis: Feedforward Strategic Explanation
5. Liquidity Analysis: Feedback Screen
7. Liquidity Analysis: Feedback How Explanation
8. Liquidity Analysis: Feedback Strategic Explanation
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Sales to Cash and Equivalents
- Sales to Receivables
- Sales to Inventories
- Sales to Working Capital
- Sales to Net Prop., Plant and Equip.
- Sales to Other Noncurrent Assets
- Return on Long-Term Liab. and Equity
- Return on Sales [%]
- Return on Assets [%]
- Return on Equity [%]
- Asset Turnover
- Before Tax Return on Total Assets
- Return on Sales [%]
- Sales to Current Liabilities
- Financial Leverage
- Screen Control
Financial leverage indicates the leverage inherent in the financing of the company's assets from the perspective of the common shareholders. A high value for this ratio signifies that management is using large amounts of debt financing in relation to equity. This is an important determinant of overall profitability to the common shareholders.
Asset Utilization and Profitability Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.

Financial Leverage Ratio =

\[
\frac{\text{Average Total Assets}}{\text{Average Shareholders Equity}}
\]
Asset Utilization and Profitability Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.
Canacom's management is following a policy of accepting a lower asset turnover for higher gross margins. This is paying off currently in the form of better-than-industry return on assets as the increase in the return on sales more than offsets the expense of the lower asset utilization rates. However, there is a concern about Canacom's ability to continue this policy in the future, especially in the face of the increased competition of the electrical and electronic products marketplace.

Assets utilization ratios have been on a declining trend. Management should consider seriously the trade-offs between the benefit of holding back each particular class of assets and the cost of tying up funds in that class of assets. The declining trend suggests that management is having a low level of success in coping with the changing business environment.
An assessment of the changes in the turnover rates of individual asset categories is an essential step in evaluating management's success in generating sales and producing profits out of every dollar invested in assets. It also provides an indication of how well the firm is coping with the changing business environment, that is in Canacom's case, its move into microcomputers, software, and related peripheral equipment. A persistent and "across-the-board" drop in the individual asset utilization rates, as is the case with Canacom, is of concern as it can adversely impact future profitability and liquidity. While a small reduction in the utilization ratios could be expected due to an increased amount of self-manufacturing in the industry, a drop to a level which is significantly below the industry composites is a serious concern.
This conclusion is based on the following series of evaluations:

1) Sales to Cash Equivalents has dropped from 32.3 to 8.80 in five years;
2) Sales to Receivables has dropped from 76.7 to 23.0 in five years;
3) Sales to Inventory has dropped from 3.2 to 2.9 in five years;
4) Sales to Working Capital has dropped from 3.9 to 2.5 in five years;
5) Asset Turnover has dropped from 1.99 to 1.56 in five years.

Comparisons to industry composites also reveal that all the above ratios are now below the industry average.
The following conclusions have been reached by the system. Please specify your level of agreement.

**ASSET UTILIZATION & PROFITABILITY ASSESSMENT**

- **Assessment of Market Growth & Trends**
  - [Rapid Expansion & Increased Competition]

- **Assessment of Margins and Return on Sales**
  - [Positive]

- **Assessment of Return on Assets**
  - [Positive]

- **Profitability Assessment [ROE]**
  - [Positive/Declining]

- **Asset Utilization Assessment**
  - [Negative]

- **Assessment of Financial Leverage**
  - [Declining]

- **Assessment of Working Capital Items Turnover**
  - [Negative]

- **Assessment of Fixed Assets Turnover**
  - [Positive]
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Equity to Total Debt
- Equity to Long-term Debt
- Equity to Net Property, Plant and Equipment
- Times Interest Earned
- Earnings Coverage of Fixed Charges
The equity to net property, plant, and equipment ratio compares the stockholders equity with the value of the tangible assets of the company. It is an indicator of the company's liquidation or break-up value.
Capital Structure Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.

Equity to Net Property, Plant and Equipment Ratio =

\[
\frac{\text{Stockholders Equity}^*}{\text{Net Property, Plant, and Equipment}}
\]

[* Adjusted for deferred income taxes]
Capital Structure Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

1. The company has been choosing to finance its operations through equity rather than debt in the last five years. This has moved it from a below average solvent position to an above average solvent position. It now has great capacity to safely take on significant new debt.

   Agreement With Above Conclusion?
   
   STRONGLY AGREE: 1 2 3 4 5 6 7
   STRONGLY DISAGREE

2. There is a concern as to Canacom's ability to grow. It is not optimizing its ability to obtain financing to fully realize the growth potential of the high technology industry. The significantly high level of equity suggests that conservative capital structure management may be holding back Canacom's strategic potential.

   Agreement With Above Conclusion?
   
   STRONGLY AGREE: 1 2 3 4 5 6 7
   STRONGLY DISAGREE
An assessment of the balance between debt and equity is critical for understanding the extent to which nonequity capital is used to finance the assets of the firm. This understanding of the leverage risk involved is critical to the evaluation of the level of additional debt financing that the firm can take on without materially affecting its susceptibility to debt default.
The following conclusions have been reached by the system. Please specify your level of agreement.

This conclusion was reached based on the following factors:

1) the equity to debt ratio has risen from 0.54 to 2.50 in five years and is now much higher than the relevant industry composites of between 0.46 and 0.92.

2) the equity to long-term liabilities has risen from 0.83 to 6.80 in five years compared to the current industry composites of 2.19 and 3.89.

3) the equity to net property, plant and equipment ratio has risen from 1.36 to 4.39 in five years and is now above the industry composites of 1.69 and 2.10.

4) while the absolute amount of debt the firm is carrying has increased by approximately 60 million in the last five years, shareholders equity has risen by approximately 913 million in the same period.
The following conclusions have been reached by the system. Please specify your level of agreement.

**Assessment of Leverage Risk** [Positive]

**Assessment of Capital Structure Management** [Too Conservative]

**Assessment of Fixed Assets Coverage** [Positive]

**Scope for Debt** [Positive]

**Balance Between Debt-Equity** [Equity]

**In Relation to Industry and Operating Management** [Positive]

**In Relation to Market Growth and Investment Opportunities** [Negative]

**Non-payment Default Risk** [Positive]

**Scope for Increased Charges** [Positive]

Note: Results of the various assessments are given in red and in brackets.
All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation button. At end, please click on START ANALYSIS to proceed.

- Current Ratio
- Acid-Test Ratio
- Accounts Receivable Turnover
- Inventory Turnover
- Day Sales in Receivables
- Oper. Cash Flow to Total Curr. Liab.
- Days to Sell Inventory
- Conversion Period (days)
- % Cash to Current Assets
- % Cash to Current Liabilities
- Working Capital (million $)
- Liquidity Index
The liquidity index is a weighted index that measures the turnover of current assets. It aggregates the information provided by the more specific indices of liquidity. It is useful if compared to past years and to other firms.
Liquidity Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.

Liquidity Index =

\[
\frac{(\text{Accounts Receivable \times Days Sales in Receivables}) + (\text{Inventory \times Conversion Period})}{(\text{Total Current Assets} - \text{Other Current Assets})}
\]
Liquidity Analysis

All the following inputs will be used by the system as part of its analysis. Should you wish to receive explanations about any of them, click on the appropriate radio-button followed by a click on the relevant explanation.

STRATEGIC EXPLANATION - [FFST6-11.txt]

LIQUIDITY ANALYSIS

- Liquidity Index
  - Current Condition Review
  - Operational Impact Review
    - Working Capital
      - Cash to Current Assets
      - Current Ratio
    - Acid-Test Ratio
    - Cash to Current Liabilities
  - Inventory
    - Days to Sell Inventory
    - Inventory Turnover
  - Cash Flow
    - Cash to Total Current Liabilities
    - Operating Cash Flow to Total Current Liabilities
  - Receivables
    - Accounts Receivable Turnover
    - Day Sales In Receivables
The following conclusions have been reached by the system. Please specify your level of agreement with each of them. To receive explanations about them, click on the appropriate radio-button that precedes each conclusion, followed by a click on the relevant explanation button. At end, please click on NEXT-SCREEN to proceed.

○ Canacom is in a very favourable working capital position indicating little risk in the short term of financial disaster. It would be an optimal client for a short-term loan.

**Agreement With Above Conclusion?**

<table>
<thead>
<tr>
<th>STRONGLY AGREE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>STRONGLY DISAGREE</th>
</tr>
</thead>
</table>

○ There is an increasing trend toward having a high proportion of sales on credit. While the proportion has tripled in the last five years, it still remains within a range well below industry levels.

**Agreement With Above Conclusion?**

<table>
<thead>
<tr>
<th>STRONGLY AGREE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>STRONGLY DISAGREE</th>
</tr>
</thead>
</table>
The following conclusions have been reached by the system. Please specify your level of agreement.

The reasons underlying this trend are important indicators of the company's ability to manage current assets. An increasing trend can indicate:

1) higher sales by credit customers or lower sales by cash customers,

2) higher credit limits or longer payment terms offered to customers, or

3) poor collection practices or unrecorded bad debts.
The following conclusions have been reached by the system. Please specify your level of agreement.

This conclusion was reached based on the following evaluations:

1) the day sales in receivables ratio over the last five years has increased from 4.80 to 15.90,

2) the accounts receivables turnover has declined from 76.73 to 23.02 over five years, and

3) the proportion of receivables to total assets in the common-size balance sheet has increased from 3 to 7 percent.
The following conclusions have been reached by the system. Please specify your level of agreement.

### STRATEGIC EXPLANATION - [FBST6-2.bat]

**LIQUIDITY ASSESSMENT**

- **Assessment of Working Capital**
  - Positive
- **Assessment of Receivables Management**
  - Negative
- **Assessment of Inventory Management**
  - Negative
- **Assessment of Cash & Equivalents Management**
  - Positive

Note: The results of the various assessments are given in red and in brackets.
APPENDIX 8:

STRUCTURAL EQUATION MODELLING:

Appendix 8A: Comparison of the PLS and LISREL Methods of Structured Equation Modelling

Appendix 8B: Summary of Secondary PLS Models Fitted
Appendix 8A: Comparison of the PLS and LISREL Methods of Structured Equation Modelling

Fornell [1982] terms statistical techniques such as multiple regression, multiple discriminant analysis, analysis of variance and covariance, principal components analysis, and canonical correlation as the first generation of multivariate analysis procedures. These techniques suffer from major weaknesses relating to the assumptions that have to be made before they can be used. These include: 1) that constructs can be measured by single indicators as in regression analysis; 2) that data will be distributed in multivariate normal fashion; 3) that by aggregating variables to form variate scores and then testing the relationships between these variates, the links between the component variables in each variate are portable across theoretical contexts; and 4) that measurement error, which is unavoidable, can be estimated outside the context of the theory being tested. To overcome these and other weaknesses, Fornell suggests that a second generation of multivariate analysis techniques are appropriate that facilitate: 1) the analysis of multiple criterion and predictor variables, 2) the contextual analysis of measurement errors, and 3) the analysis of unobservable theoretical and definitional variables.

The Partial least squares (PLS) [Wold, 1979] and linear structural relationships (LISREL) [Joreskog and Sorbom, 1984] models represent the two most prominent exemplars of this new generation of multivariate statistical techniques that are often collectively termed path analysis, latent variable modelling, causal modelling, and structural equation modelling. While LISREL has been the most commonly used technique, it is increasingly becoming clear that it cannot
realistically be assumed that all problems amenable to structural equation modelling are also automatically suited to LISREL. PLS offers a significantly different yet more robust protocol for structural estimation that imposes different and less stringent assumptions about data, sample size, theory, and the links between unobservable latent variables and observable manifest variables. Considering the differences in the structure and objectives of PLS and LISREL, the choice between them is neither arbitrary nor simple, rather the general research setting should dictate the selection.

LISREL is based on covariance structure analysis with the maximum likelihood estimation of parameters. PLS on the other hand minimizes residual variances under the constraints of fixed point estimation [Wold, 1979]. It operates as a series of interdependent ordinary least squares regressions, presuming no distributional form at all. An analysis of the recent literature [Fornell, 1982; Fornell and Bookstein, 1982; Lohmoller, 1982; Higgins, Barclay and Duxbury, 1990] on the comparative value of the two methods reveals the following:

1. LISREL is suited to research problems where there is strong theory to guide the model formulation and confirmation, while PLS is just as suitable in situations with less developed theory [Higgins et al, 1990]. The use of PLS is therefore sensible in earlier stages of theory development and LISREL at the later confirmatory stages.

2. LISREL requires that data is multivariate normal in distribution and interval-scaled for purposes of maximum likelihood estimation. PLS estimation does not involve a statistical model
and thus makes minimal demands about measurement scales, sample size and the distribution of residuals. Nominal, ordinal, and interval-scaled variables are permissible in just the same ways as in ordinary regression. Additionally, dichotomous variables can be easily handled in PLS without having to resort to "fixing" variables or to several-group analysis as is inevitable in LISREL.

3. LISREL requires relatively large sample sizes for accurate estimation and relatively few variables and constructs for convergence. Generally, a ten-to-one ratio between the number of cases required and the number of parameters to be estimated is used and it is uncommon to find LISREL studies that have had sample sizes of less than one hundred cases. PLS, on the other hand, can deal with much smaller samples because its iterative algorithm estimates parameters in only small subsets of an overall model during any given iteration. Higgins et al [1990] note that the subset estimation process consists of simple and multiple regressions so that the sample required is that which would be sufficient for the most complex multiple regression encountered. Wold [1979] goes so far as to suggest that small sample sizes, sometimes even smaller than the number of variables, can be sufficient for descriptive PLS analysis.

4. LISREL considers unobserved or latent constructs as being underlying factors that are reflected by sets of observable manifest variables. All latent variables in any LISREL have to be defined in this manner. PLS while allowing for such reflective indicators, also facilitates the definition of latent constructs as being formative indices produced by sets of observable indicators. The choice of formative and reflective indicators in PLS is not merely a matter of
empirical statistical decision making, rather it brings conceptual, theoretical and empirical considerations to bear together on the objectives of the modelling being undertaken.

5. LISREL has as its objective the *explanation* of empirical data structure by focusing on model fitting. It attempts to estimate model parameters by minimizing the discrepancies between the empirical covariance matrix and the covariance matrix inferred from the model structure and the parameter estimates. PLS, on the other hand, focuses on the *prediction* of the theoretical and/or empirical variables in the traditional regression sense. It performs this by attempting to minimize residual variance in a model using incremental ordinary least squares regressions.

6. The path-analytic fitting objective that underlies LISREL can often lead to two fundamental problems. This are the problems of having *improper solutions*, i.e., solutions obtained are outside the admissible parameter space, and *factor indeterminacy* which by manifesting itself in the form of improper factor loadings and negative variances can render a model as either having multiple interpretations or no interpretation at all. PLS avoids such problems by explicitly defining the observables. Thus, in situations where model fit is expected to be problematic, PLS is the more feasible way to go. Lohmoller [1982] found that even for large models with many variables and constructs PLS converged more quickly than LISREL.

In summary, second generation multivariate analysis tools, like LISREL and PLS, provide the capability to advance understanding by combining theoretical and empirical knowledge to an extent not possible with conventional first generation multivariate statistical
techniques [Fornell, 1982]. Considering the factors that distinguish between the PLS and LISREL methods, PLS was selected as the more feasible alternative for this study. This selection was supported by the following considerations:

1. The laboratory experimental nature of the study and the fact that experienced financial analysts were not easily accessible necessitated that the sample size be limited to 80 subjects. This is small in relation to LISREL's requirements.

2. The study has a strong exploratory character. Research into the factors that determine the use of KBS explanations and the consequences of this use is at the infancy stage of theory formation.

3. The structural equation model fitted, as depicted in Figure 6.19 of Chapter 6, included both formative and reflective indicators. For example, the use of KBS explanations was "formed" by a combination of separate measures relating to each of the three types of explanations provided, while judgmental accuracy was "reflected" in the eight judgments that were made by subjects. Similarly, user expertise was "formed" by the number of years of experience that subjects possessed and their educational and professional qualifications.

4. Both the two main independent variables --- user expertise and the feedforward/feedback provision of explanations, were categorical, non-interval measures and therefore could not be easily handled by LISREL.
Appendix 8B: Summary of Secondary PLS Models Fitted

This appendix describes the second structural equation model that was fitted using the Partial Least Squares method, and presents the results of this model. The primary model (Figure 6.19) that was described in Chapter 6 was run with the data from all 80 subjects and it only considered the paths between the latent variables that were hypothesized in this research. The second model was attempted for a few reasons. First, there was the concern that it was inappropriate to include the data from all 80 subjects because some of the subjects had no scores for the indicators of the use of explanations. For example, since the controls groups did not receive any explanations at all, they had no measures recorded for the use of explanations. Second, it was felt that introducing other paths, besides those that were directly investigated in this research, would serve to enrich the meaning of the model. Third, it was felt that the inclusion of explanation provision strategy as a latent variable measured by two binary (0, 1) variables (as in Figure 6.19) possibly reduces the conceptual clarity of the model. This is because explanation provision strategy represents a variable that was explicitly manipulated in the study.

Figures A8.1, A8.2, and A8.3 show the structure of the revised, second model that was fitted. As explanation provision strategy was dropped as a latent variable, the model had to be fitted separately for the subjects who received different sets of explanations. Figure A8.1 shows
the model that was fitted to the data from the subjects who received both feedforward and feedback explanations. Figure A8.2 shows the model that was fitted to the data from the subjects who received only feedback explanations, and Figure A8.3 shows the model as applied to the data from the subjects who received only feedforward explanations. The model was not fitted to the data from the control groups that received no explanations, as without the explanation use latent variable the model would have been unmeaningful. An important distinction between these models is the manner in which the use of explanations latent variable is modelled. In Figures A8.2 and A8.3 it is modelled using only three indicators, corresponding to the usage scores for the Why, How, and Strategic explanations. However, in Figure A8.1 it is modelled as a second-order factor using the repeated indicators approach [Lohmoller, 1989]. This was because when both feedforward and feedback usage scores are included the use of explanations variable represents a multi-dimensional construct. An examination of the loadings of the indicators for this variable in Figure A8.1 reveals that they are significantly higher (ranging from 0.55 to 0.87) and more consistent than those that were obtained in the model of Figure 6.19.

Additionally, the three models also included two new paths that were not included in Figure 6.19. These are the paths from user expertise to accuracy and from user expertise to the perceptions of usefulness. A direct impact of adding these paths can be seen in the increased multiple $R^2$ values for the accuracy of judgments and the perceptions of usefulness. For example, while the multiple $R^2$ for the accuracy of judgments was only 4% in the model of Figure 6.19, in these models it ranges from 52% to 71%. This is because the path from user expertise to the accuracy of judgments explains a large portion of the variance in the latter. The results for the
perceptions of usefulness are generally similar but of lesser magnitude, with the highest multiple $R^2$ being 36% in Figure A8.1.

The blindfolding technique [Lohmoller, 1989] was used to test the significance of the path coefficients between the latent variables. Only one path was found to be not significant at the 0.05 level of alpha. This was the path from user expertise to the perceptions of usefulness in Figure A8.2. As can be expected the paths with the largest coefficients were those from user expertise to the accuracy of judgments. The paths from the use of explanations to the accuracy of judgments were moderately strong, ranging from 0.16 to 0.28 for the three models. The paths from the use of explanations to user perceptions of usefulness (ranging from 0.05 to 0.60) and from user expertise to the use of explanations (0.21 to 0.50) show a larger degree of variance between the three groups.

A major weakness of structural equation modelling using the PLS method is the absence of a procedure or metric for comparing different models. This is especially critical from the perspective of data from experimental studies such as this, where some variables are expressly manipulated or controlled in an effort to learn from the comparison of the various treatment groups. Analysis of the three models of Figure A8.1, A8.2, and A8.3, while being in itself useful, offers few insights as to the hypothesized relationships of the study.
List of PLS Models Included:

Figure A8.1: Structural Equation Model For Subjects Receiving Both Feedforward and Feedback Explanations (N = 20)

Figure A8.2: Structural Equation Model For Subjects Receiving Only Feedback Explanations (N = 20)

Figure A8.3: Structural Equation Model For Subjects Receiving Only Feedforward Explanations (N = 20)
FIGURE A8.1:
STRUCTURAL EQUATION MODEL
FOR SUBJECTS RECEIVING BOTH
FEEDFORWARD & FEEDBACK
EXPLANATIONS (N = 20)

* significant at p < 0.05
FIGURE A8.2:
STRUCTURAL EQUATION MODEL
FOR SUBJECTS RECEIVING ONLY
FEEDBACK EXPLANATIONS (N = 20)

* significant at p < 0.05
FIGURE A8.3:
STRUCTURAL EQUATION MODEL
FOR SUBJECTS RECEIVING ONLY
FEEDFORWARD EXPLANATIONS (N = 20)

* significant at p < 0.05
APPENDIX 9:

TASK MATERIAL AND SUMMARY DATA OF THE PILOT TEST

UNDERTAKEN TO VALIDATE THE EXPLANATIONS
Financial Analysis Expert Systems Study

What type of explanation is this? ____________________

Explanation Reference: ________

1. In my opinion, this explanation is easy to understand.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

2. This explanation provides the information that I had expected to receive for it.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

3. In my opinion, this explanation is easy to read.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

4. I am familiar with the grammar and vocabulary used in this explanation.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

5. In my opinion, this explanation adequately meets the definition of its category as presented.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

6. The meaning of this explanation is clear and obvious.
   Strongly Disagree: 1 -- 2 -- 3 -- 4 -- 5 -- 6 -- 7 : Strongly Agree

Comments and suggestions for improving this explanation:

________________________________________
________________________________________
________________________________________

450
EXPLANATION DEFINITIONS: FEEDFORWARD

Expert systems provide three kinds of explanations. These are termed the WHY, HOW, and STRATEGIC explanations and are defined as follows:

1. WHY explanations justify the importance of, and the need for, input information to be used or a procedure that is to be performed. For example, in the financial analysis case, this could be a justification for a ratio, e.g. the acid-test ratio, or a particular procedure, e.g. a trend comparison.

2. HOW explanations detail the manner in which input information is to be obtained and procedures to be performed. For example, in the financial analysis case, this could be how an input ratio is to be computed or how a trend comparison procedure is to be performed.

3. STRATEGIC explanations provide information about the overall manner in which input information to be used is organized or structured. For example, in the financial analysis case, this could take the form of an organizational knowledge structure of the objectives of the inputs and procedures to be used for a particular analysis, e.g., liquidity analysis.
EXPLANATION DEFINITIONS: FEEDBACK

Expert systems provide three kinds of explanations. These are termed the WHY, HOW, and STRATEGIC explanations and are defined as follows:

1. WHY explanations provide a justification for a conclusion that is reached by the system. They emphasize the importance of a particular conclusion and clarify its implications.

2. HOW explanations detail the manner in which a particular conclusion is reached. They emphasize the evaluations performed and intermediate inferences made in getting to a particular conclusion. They represent a trace of the factors that underlie the reaching of the conclusion.

3. STRATEGIC explanations provide information about the overall goal structure used by a system to reach a conclusion. They clarify the manner in which a particular assessment leading to a conclusion fits into the overall plan of assessments made as part of an analysis. For example, in the financial analysis case, this could take the form of an hierarchical control structure of the various kinds of assessments performed for a particular analysis, e.g., liquidity analysis.
### Table A9.1: Detailed Statistics for Understandability of Explanations

<table>
<thead>
<tr>
<th>Type of Explanation</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item 1</td>
<td>Item 6</td>
<td>Item 1</td>
</tr>
<tr>
<td>Why</td>
<td>6.17 (0.76)</td>
<td>6.08 (0.77)</td>
<td>6.08 (0.85)</td>
</tr>
<tr>
<td>How</td>
<td>6.40 (0.70)</td>
<td>6.30 (0.81)</td>
<td>6.14 (0.92)</td>
</tr>
<tr>
<td>Strategic</td>
<td>6.03 (0.95)</td>
<td>5.89 (0.98)</td>
<td>6.10 (0.91)</td>
</tr>
<tr>
<td>Total</td>
<td>6.20 (0.82)</td>
<td>6.09 (0.87)</td>
<td>6.10 (0.89)</td>
</tr>
</tbody>
</table>

Legend: The data is in the form: Mean (Standard Deviation)

### Table A9.2: Detailed Statistics for the Readability of Explanations

<table>
<thead>
<tr>
<th>Type of Explanation</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item 3</td>
<td>Item 4</td>
<td>Item 3</td>
</tr>
<tr>
<td>Why</td>
<td>6.22 (0.76)</td>
<td>6.53 (0.76)</td>
<td>6.05 (0.94)</td>
</tr>
<tr>
<td>How</td>
<td>6.52 (0.73)</td>
<td>6.69 (0.60)</td>
<td>6.23 (0.93)</td>
</tr>
<tr>
<td>Strategic</td>
<td>6.00 (1.06)</td>
<td>6.56 (0.85)</td>
<td>6.19 (1.15)</td>
</tr>
<tr>
<td>Total</td>
<td>6.25 (0.89)</td>
<td>6.59 (0.75)</td>
<td>6.16 (1.01)</td>
</tr>
</tbody>
</table>

Legend: The data is in the form: Mean (Standard Deviation)
Table A9.3: Detailed Statistics for How Accurately the Explanations Meet Their Definitions

<table>
<thead>
<tr>
<th>Type of Explanation</th>
<th>Feedforward</th>
<th>Feedback</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item 2</td>
<td>Item 5</td>
<td>Item 2</td>
</tr>
<tr>
<td>Why</td>
<td>6.18</td>
<td>6.09</td>
<td>6.15</td>
</tr>
<tr>
<td></td>
<td>(0.70)</td>
<td>(0.85)</td>
<td>(0.75)</td>
</tr>
<tr>
<td>How</td>
<td>6.47</td>
<td>6.18</td>
<td>6.38</td>
</tr>
<tr>
<td></td>
<td>(0.72)</td>
<td>(0.79)</td>
<td>(0.76)</td>
</tr>
<tr>
<td>Strategic</td>
<td>6.03</td>
<td>5.99</td>
<td>6.02</td>
</tr>
<tr>
<td></td>
<td>(0.98)</td>
<td>(1.02)</td>
<td>(0.99)</td>
</tr>
<tr>
<td>Total</td>
<td>6.23</td>
<td>6.09</td>
<td>6.18</td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(0.89)</td>
<td>(0.85)</td>
</tr>
</tbody>
</table>

Legend: The data is in the form: Mean (Standard Deviation)