1-1-2002

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Raj Gururajan
Edith Cowan University

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Raj GURURAJAN

Supervisor: Associate Professor Dieter FINK

USE OF THESIS

A Study of the Influences of Computer Interfaces and Training Approaches on End User Training Outcomes

by

Raj GURURAJAN

MASc (India), GDAS (Cowan)

Student ID: 089 5155

A Thesis Submitted for the Fulfilment of the Requirements for the Award of Doctor of Philosophy in Business Studies

At the Faculty of Business and Public Management

Edith Cowan University

Churchlands

Supervisor: Associate Professor Dieter FINK

Date of Submission: 14 NOV 2002

DECLARATION

I certify that this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in my institution of higher education and that, to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text

Signature: ___ ___________

Date: 14 NOV 2002

ACKNOWLEDGEMENTS

I thank Associate Professor Dieter Fink for his supervision of this research. His guidance, encouragement and expertise were valued throughout this study. His support gave me the strength to complete the thesis.

I would like to thank Judith Rochecouste who reviewed the thesis a number of times without which this thesis would have not been complete. I would like to thank Mr. Bill Laidman and Dr. David McDoughall who reviewed specific chapters and made comments on their validity and appropriateness.

I would like to thank my parents, my wife Vijaya who stood by me for the past five years and tolerated my absence from home activities. I would also like to thank my daughter Rashmi for her continual support, love and encouragement, without which I would have not completed this thesis. I would like to thank a number of friends at Edith Cowan University who reviewed the research design, who helped me to collect experimental data and who provided advice from time to time. My special thanks are also due to Carol Dixon, the School of Computer and Information Science Secretary at Edith Cowan University, who organised entry to my office building during Christmas break and Helen Mondello, who organised special offices for me to write the thesis without interruption.

I finally thank the God Almighty, who gave me the mental and physical strength to undertake the research.

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ABSTRACT

Effective and efficient training is a key factor in determining the success of end user computing (EUC) in organisations. This study examines the influences of two application interfaces, namely icons and menus, on training outcomes. The training outcomes are measured in terms of effectiveness, efficiency and perceived ease of use. Effectiveness includes the keystrokes used to accomplish tasks, the accuracy of correct keystrokes, backtracks and errors committed. Efficiency includes the time taken to accomplish the given tasks. Perceived ease of use rates the ease of the training environment including training materials, operating system, application software and associated resources provided to users.

In order to facilitate measurement, users were asked to nominate one of two approaches to training, instruction training and exploration training that focussed on two categories of users, basic and advanced. User category was determined based on two questionnaires that tested participants' level of knowledge and experience. Learning style preference was also included in the study. For example, to overcome the criticisms of prior studies, this study allowed users to nominate their preferred interfaces and training approaches soon after the training and prior to the experiment.

To measure training outcomes, an experiment was conducted with 159 users. Training materials were produced and five questionnaires developed to meet the requirements of the training design. All the materials were peer reviewed and pilot tested in order to eliminate any subjective bias. All questionnaires were tested for statistical validity to ensure the applicability of instruments. Further, for measurement purposes, all keystrokes and time information such as start time and end time of tasks were extracted using automated tools. Prior to data analysis, any 'outliers' were eliminated to ensure that the data were of good quality.

This study found that icon interfaces were *effective* for end user training for trivial tasks. This study also found that menu interfaces were *easy to use* in the given training environment. In terms of training approaches, exploration training was found to be *effective*. The user categorisation alone did not have any significant influence

on training outcomes in this study. However, the combination of basic users and instruction training approach was found to be *efficient* and the combination of basic users and exploration training approach was found to be *effective*. This study also found out that learning style preference was significant in terms of *effectiveness* but not *efficiency*.

The results of the study indicates that interfaces play a significant role in determining training outcomes and hence the need for training designers to treat application interfaces differently when addressing training accuracy and time constraints. Similarly, this study supports previous studies in that learning style preferences influence training outcomes. Therefore, training designers should consider users' learning style preferences in order to provide effective training. While categories of user did not show any significant influence on the outcomes of this study, the interaction between training approaches and categories of users was significant indicating that different categories of users respond to different training approaches. Therefore, training designers should consider the possibility of treating differently those with and without experience in EUC applications. For example, one possible approach to training design would be to hold separate training sessions.

In summary, this study has found that interfaces, learning styles and the combination of training approaches and categories of users have varying significant impact on training outcomes. Thus the results reported in this study should help training designers to design training programs that would be effective, efficient and easy to use.

CHAPTER 1 – INTRODUCTION

For a business organisations to operate successfully, the Information Technology (IT) potential of an organisation needs to be examined, which includes software resources, hardware resources, the capability of users in developing IT applications, the capability of Information System (IS) development, vendor off-the shelf applications used in organisations and applications developed by outsource companies (Shah & Lawrence, 1996). The examination of software resources typically involves the operating system platforms used in the organisation, the number of users using these systems, the software development capability available within the organisation, and now-a-days the World Wide Web (WWW) platform and access, resources associated with Internet and Intranet applications (Beekman & Rathswohl, 1999). An examination of hardware resources consists of type of computer hardware including memory, hard disks and other peripheral resources, and the network capability (Williams et al., 1995). An examination of vendor off-the shelf applications and outsourcing includes the appropriateness of software applications procured from external sources and issues associated with integration of these applications with the existing systems and training needed to integrate user operations arising from these new systems with existing systems (Beekman & Rathswohl, 1999; Shayo et al., 1999).

The capability of an organisation to exploit the above hardware and software resources is dependent on the capabilities of Information Systems (IS) professionals following traditional approaches and development performed by users who may not have professional knowledge in developing computing applications (Shayo et al., 1999). Among these, the capability of users without professional computing background developing systems is usually known as 'End User Computing' (Blili et al., 1998). This End User Computing (EUC) domain has emerged strongly as one of the organisational success factors because of its contribution to the use of IS in organisations (Compeau, 2002).

The proliferation of EUC in organisations has been widely reported in the past two decades (Jawahar & Elango, 2001). A survey of senior Information Systems professionals has found that organisational learning and use of Information Technology (IT) by users rank fifth in a list of the top 20 critical management issues (Chaney & Wills, 1995). Aggarwal (1998) and Finley (1996) highlighted the need and high priority in preparing the workforce to use IT productively in an organisation by referring to the increase in IT training budgets. Bowman et al. (1994) reported the escalating growth in computer literacy requirements for clerical and support staff. Olsten (1993) reported the necessity for acquiring computer literacy for middle and senior management in organisations. Bostrom et al. (1990) and Rivard & Huff (1988) reported the success or failure of EUC within an organisation.

It appears that the lack of skills possessed by end users is a major restriction in the development of end user applications (Compeau, 2002). This lack of development skills prompted the creation of training programs and encouraged human resources departments to focus on end user training issues such as what is the best method to train users (Shah & Lawrence, 1996). Furthermore, it si suggested that basic and advanced training should be integral elements of any strategy designed to enhance end user efficiency and effectiveness (Tang & Cheung, 1996). It is estimated that the cost to train an end user is about Australian $ 2,000 per year and the cost to maintain an end user in an organisation varies from $ 7,000 to $12,000 (Ridge, 1999).

User training has been identified as one of the key factors responsible for ensuring the success of EUC and this has resulted in EUC training becoming an important phenomenon in organizations (Sein et al., 1999). Researchers have continually sought to improve the delivery of training programs by employing new methods or by improving existing methods. Through the improvement in design and conduct, for example, Aggarwal (1998), Blili et al. (1998) and Bohlen & Ferrat (1997) have endeavored to make training more effective and efficient. Improvement in training ensures that end users interact more effectively with software programs and applications. In endeavouring to measure the efficiency and effectiveness of training programs, EUC studies have focused on aspects such as user skills (Davis & Bostrom, 1993), user satisfaction (Olfman & Mandviwalla, 1995), use of application interfaces in order to quickly complete a given task (Sein et al., 1993), training materials (Carrol & Rosson, 1995), motivational factors on computer usage (Barker, 1995), performance and job satisfaction (Blili et al., 1998) and quality of end user developed applications (Cheney et al., 1986).

Studies in EUC that have measured aspects of user skills investigated how users transform their knowledge acquired during training to accomplish a given task in a specified settings. Studies that have measured user satisfaction investigated factors determining user satisfaction in a given training environment. Studies that have considered interfaces have examined how a specific type of interface is superior to another type in accomplishing tasks. Issues associated with training materials such as task complexity have been examined in studies that have investigated aspects of training materials. Motivational factors leading to the use of application software were investigated in EUC studies.

In spite of previous research there is still little agreement about how to design end user training programs that would yield efficiency and effectiveness. The literature indicates that problems associated with EUC training remain such as over-extending experience gained in manual systems that are not suitable for computer systems (Moran, 1981), inability in recalling and using application command syntax (Sein et al., 1993), difficulty in applying software packages to specific tasks (Carrol & Rosson, 1995), unstructured training materials and hence negative influences on the user (Gustafson & Branch, 1997), and confusion about how to recover from errors (Olfman & Mandviwalla, 1995).

While attention has correctly been focussed on training program design, an important factor is the computer interface itself. Interfaces (specifically the usage aspect) can spell the difference between systems that are comprehensive and easy to use and systems that are frustrating, confusing and in the end may not be used at all. Bostrom et al. (1990) related the cognitive aspects underlying computer use with the effectiveness of computer interfaces. The cognitive makings of end users in addition to the design of training programmes therefore need to be investigated in EUC research.

End user training programs can be addressed in a variety of ways. For example, Nelson et al. (1995) distinguished between how quickly an end user can complete a given task and how accurate the completion is. In other words, the time component and the accuracy component are considered critical for successful training. The time component is referred as efficiency and the accuracy component is identified through allocation of some points gained in accomplishing tasks, similar to practical examination score. In addition, studies have investigated the ease of the training environment (Bohlen & Ferrat, 1997) and the motivational factors (Olfman & Mandviwalla, 1995; Sein et al., 1999) which influence end users in choosing software applications and continuing to use them. These issues have provided the impetus for this study.

Therefore this study was commenced in order to determine the influences of the usage of specific types of interfaces and training approaches on categories of end users in terms of training outcomes efficiency, effectiveness and perceived ease of use. With this scope in mind, this chapter gives an introduction to this study by providing an overview to EUC studies conducted since 1980. The starting point was chosen as 1980 because this is when the term EUC was generally accepted by the information systems community (Mayer, 1981). This introduction then leads to research objectives followed by significance of the study. Then an initial research framework to meet the research objectives is provided. The chapter concludes with an outline of the thesis.

Research objectives

The objectives of this study can be encapsulated in the following five points:

1. It can be seen from the previous paragraphs that while EUC studies have provided information regarding the usage of interfaces, little information is available as to the suitability of interfaces for varying levels of knowledge and experience. Therefore, there is a need to determine the most appropriate interface usage for different categories of end users to learn application software packages.

2. EUC studies have provided details of training approaches as a result of investigation into instructional design elements. While training approaches have been dealt with in EUC studies, the relevance of these training approaches on different categories of users is not fully established in EUC. Further, how these training approaches influence user's ability to use an interface for the purpose of communication with applications is not fully understood. Therefore, there is a need to determine the most suitable training approach and interface combinations for various levels of end users.

3. EUC literature provides limited information on classifying users based on both their knowledge and skills. Some studies have classified users based on their skills and some others have done so based on knowledge. However, there are references in the literature that both knowledge and experience help users to understand the given information in a specific context and that this knowledge and experience combination helps the user to process information in novel situations. This is especially true when users are given a choice of interfaces with which to accomplish tasks. Certain interfaces are easier to use than other interfaces. Therefore, there is a need to determine the most suitable application software interface to facilitate efficient and effective training outcomes based on varying skills and experience.

4. Training outcomes depend upon the combination of interface usage and training approaches. While certain training approaches such as the instruction approach are better suited to certain groups of users, other training approaches such as exploration provide freedom to explore and learn on a trial and error basis. Therefore, there is a need to investigate the interaction between the training approaches and interface combination in determining training outcomes.

5. Finally, prior EUC studies have highlighted the need to consider the role of individual differences in training programs because user learning preferences and other traits such as motivation influence training outcomes. While prior studies have provided details of motivational aspects, there is limited information available on learning styles and their influences on EUC training outcomes. Therefore, there is a need to determine the role of individual user differences in determining training outcomes.

Significance of the study

The significance of the study lies in its ability to remedy some of the weaknesses found in previous EUC training research. This can be achieved by addressing five unresolved issues (1) application interfaces, (2) varying levels of users, (3) differences in terms of users' learning and cognition, (4) the design of training including training material development, such as the consideration of tasks and (5) approaches to outcome measurement. In addition, development in the field of Human Computer Interaction[1] (HCI) has seen changes in the way interfaces are designed and used. In the EUC domain, users apply knowledge obtained from training to use these interfaces. However, how the given information is processed using a specific interface based on the training provided is not fully studied in EUC. The concepts of learning style and cognitive style will play an important role in understanding how information is processed using interfaces, and how users interact with applications via interfaces. Such information is vital in order to foster development in HCI. It is essential to know how these interfaces are used, what are the influences on training outcomes and how the acquired knowledge is utilised (based on the training provided) in terms of recalling a particular interface when completing a given task. Thus, any knowledge gained from this study would assist the development of EUC training.

The result of this study will be presented in terms of the suitability of types of interfaces on varying levels of users' skills and experience because there is little evidence available in EUC to determine the suitability of interfaces for particular categories of users based on their skills and experience. Further the interaction of interfaces and training approaches will also be discussed in this thesis as users learn to operate application software based on the training provided and in the current climate these operations are performed using application interfaces. The outcomes of this study would enable organisations to determine the approach taken in training their employees.

Another dimension to the study is the planned rigorous framework in designing the training materials. There is a general view that past training materials and the tasks have been subjective in nature and that training aspects and evaluation aspects have not been strongly supported by theoretical frameworks. The framework developed for this study will not only provide a rigorous training design but will also incorporate some recent methodologies from the instructional design domain which address principles of quality.

As an additional benefit, this study will help in addressing the skills shortage in Australia. According to Ridge (1999) the IT skills shortage in Australia can be

[1] HCI is another broad area of study and only relevant issues from HCI are covered in this thesis.

temporarily resolved by providing IT training to users in order for them to become skilful. The time and cost factors are crucial in the rapidly changing IT environment and to produce IT professionals that meet the increasing demand, training programs should address efficiency and effectiveness criteria. That is, the training programs should concentrate on factors that influence outcomes such as how users' interact with applications, the composition of training materials, measurements of outcomes, users' learning preferences and the design of training to minimise resources and maximise outcomes. The outcomes of this study will provide valuable information to people involved in designing and conducting training programs.

Research framework

The discussion provided so far indicates that a study in EUC training requires further investigation. This includes consideration of interfaces, users and their individual differences, training approaches including training materials, and measurement aspects. The objectives of the study are presented in an earlier section and essentially aim to determine the effects of interface usage, the training approaches adopted and the effects of different groups of users on the outcomes of the training itself. The factors interact with each other and have an impact on training outcomes which this study aims to discover. The factors and interactions are presented in Figure 1.1 below which is followed by a brief discussion for each of the factors concerned. An elaborate discussion on these factors and their interaction is provided in a later chapter.

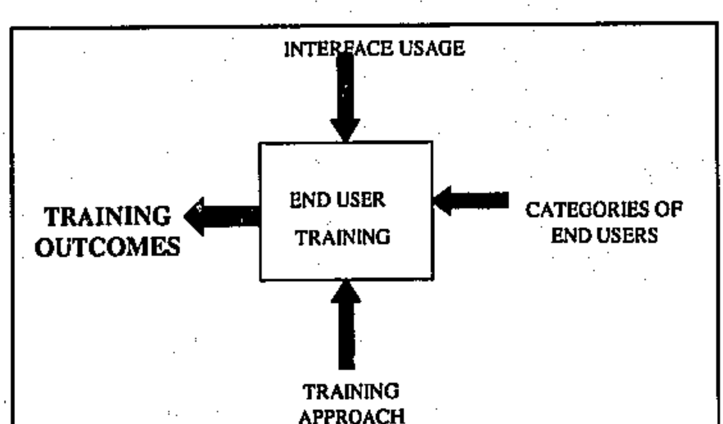

Figure 1. 1 Conceptual Framework

Bostrom et al. (1990), for example, found that command-based interfaces are dependent upon typing command strings using an editor and any typographic errors committed by users result in erroneous commands. This led to user frustration and hence impacts training outcomes. Icons, the pictorial representation of commands, on the other hand appear to be restrictive in their representations and hence the user may not be able to represent all user commands in pictorial forms. This restricts the tasks that can be accomplished using only icons. Menus are test strings and easy to understand by users as they represent user commands in a natural language form. It therefore appears that menus could reduce the load placed on cognitive dimensions while processing information thereby increasing the likelihood of successful training outcomes (Shneiderman, 1982). Previous studies in EUC that have examined the impact of interface usage on training outcomes stated that due to the limitations on icons in representing various actions facilitated by computer systems, menus appear to be a natural choice for users who want to navigate the system to perform novel tasks.

Only a few studies in EUC have identified different *categorisation of users* (examples are Carrol (1984), Olfman & Madviwalla (1995)). However, it is evident from research in the education domain that user experience plays a crucial role in comprehending the information provided during training successfully (Riding, 1991; Sadler-Smith, 1996; Schmeck, 1988) . Ausubel & Robinson (1968) argued that prior knowledge and experience have a role to play when new information is processed. According to Davis & Bostrom (1993) EUC studies have been questioned for treating users as if they have the same level of knowledge and this has been seen as one of the reasons for their contradictory training outcomes. The need to study the impact of user individual differences such as learning styles on training outcomes has been stressed by Bostrom et al. (1990), Davis & Bostrom (1993) and Bohlen & Ferrat (1997). Therefore, this study considers two categories of users, basic and experienced, based on their knowledge and experience and associated learning style issues.

Training approaches cover aspects such as how to introduce users to a given application software and how to structure tasks to meet specific objectives (Carrol & Rosson, 1995). While accomplishing given tasks, users behave differently, for instance, certain users understand given training materials easily and certain users take more time (Sein et al., 1999). A distinction in training approach can be made by identifying instruction and exploration approaches (Davies et al., 1989; Davis, 1985; Davis & Bostrom, 1993; Sein et al., 1993). The former is the execution of training materials in a sequential, step-by-step manner where users are provided with little freedom. The exploration approach on the other hand provides skeleton training material with the option for users to explore freely the given software application.

The impact of interface usage, categories of end users and training approach is measured and referred to as training outcomes in this study. The measurement comprises of quantitative and subjective outcomes. The first component, quantitative, consists of effectiveness and efficiency parameters. The quantitative outcomes capture training activities such as how many keystrokes have been used in performing a task (Davis & Bostrom, 1993). Effectiveness is a measure of score and the efficiency is a measure of time. Effectiveness and efficiency measures are derived from hands-on experiment conducted. The next component, subjective, is a measure of perceived ease of use. Perceived ease of use is measured through an opinion survey. The subjective outcomes measure users opinion of a given training environment and measure aspects such as the level of perceived ease of using the training environment (Olfman & Mandviwalla, 1995).

Based on the three main variables – interfaces, end users and training approaches – the research framework in this study will examine the effects of training approaches on the types of interfaces most commonly used by the categories of end users. The investigation will determine which combination of interfaces, training approaches and categories of end users will achieve the maximisation of training outcomes. Such outcomes will be measured in terms of efficiency, effectiveness and ease of use. A detailed discussion of the research framework will be provided Chapter 3.

Need to study EUC Training

The need to study EUC training can be highlighted by the existing and continuing unresolved research issues found in the field of EUC and the escalating costs in providing EUC training. These unresolved research issues can be categorised into five broad areas. These are (1) application interfaces, (2) varying levels of users, (3) differences in terms of users' learning and cognition, (4) the design of training including training material development, such as the consideration of tasks and (5) approaches to outcome measurement.

A study that focuses on these areas would contribute new knowledge about the impact of varying levels of user skills and their preferences for interfaces and training approaches. To identify these, one should design and develop a suitable framework. It appears that the instructional design domain can offer solutions to existing issues in EUC. So, EUC training supported with instructional design domain principles would provide a rigorous training design framework in terms of the identification of tasks, the consideration of complexity levels, the evaluation of training materials and the successful implementation of these training materials for knowledge acquisition. From an academic point of view, the outcomes of such a framework would add to the existing body of knowledge. From a management point of view, this would minimise the cost of training by providing insights into elements that need to be controlled. The essential components of such a framework are discussed below.

Interfaces

Computer interfaces facilitate interaction between humans and computers (Gentner & Nielson, 1996). Previous studies in EUC have considered command-based interfaces and Direct Manipulation Interfaces (Davies et al., 1989; Bostrom et al., 1990). Command-based interfaces facilitate users to enter English-like commands using text editors to activate a command (Bostrom et al., 1990). If errors are committed while entering these commands, a computer system will not understand the command. Therefore, users need to re-enter the command string. Studies that have investigated the effect of command-based interfaces have asserted their superiority over Direct Manipulation Interfaces (DMI) in determining training outcomes (Davis & Bostrom, 1993).

Direct Manipulation Interfaces facilitate interaction between users and computers directly with objects (Gentner & Nielson, 1996). These objects are usually graphical symbols representing an action. For example, a 'floppy diskette' symbol on a computer screen may represent a 'saving' action of data from the computer memory to the diskette. These graphical symbols are collectively known as Graphical User Interfaces or GUI (Neesham, 1990).

In computer applications, these GUIs are represented in the form of icons, menus, dialogue boxes, pointers and other optional buttons (Neesham, 1990). Users use their mouse keys to operate directly these GUIs to perform an action and hence the term Direct Manipulation Interfaces (DMI). Previous studies have highlighted the effectiveness of DMI when there are a small number of objects to represent actions (Sein et al., 1993). As the number of actions increase, so do the number of objects and DMI quickly becomes difficult to manage (Gentner & Nielson, 1996). The down side of direct manipulation is that users have to directly manipulate every action using objects and hence are restricted in actions that can be performed otherwise, as it is possible with command-based interfaces (Goonetilleke et al., 2001). Another problem with direct manipulation is that users may not be able to group a related series of basic actions into one higher-level action (Nielsen, 1990). In command-level, this can be achieved using a simple scripting language. Further, the precision of eye and hand coordination is also mentioned in previous studies in the area of DMI (Gentner & Nielson, 1996). Another problem found with DMI is that users need to be involved in every action but sometimes the user may not be aware of what needs to be done next (Gentner & Nielson, 1996). This is particularly true when the applications become more complex and users with limited knowledge may find operations with DMI to be difficult.

In the EUC domain, icons and menus can be considered as components of DMI because these two interfaces represent actions directly performed by users with mouse keys. While dialogue boxes and optional buttons also enable users to perform actions, these tools are predominantly used to interact with users to understand their scope of choices and not necessarily actions. Menu based interfaces group English-like commands and presents them to users through a hierarchical sequence of interdependent levels (Gentner & Nielson, 1996), while icon based interfaces represent various commands in a pictorial form. The hierarchical levels found in the menu interfaces are not usually found in icon interfaces (Bevan, 2001). In today's Windows applications, the menus and icons are bundled on the toolbar of the application, usually found on the top layer of the application as in Microsoft Word.

While the role of interface usage in determining training outcomes was studied extensively in the late 80's and early 90's (Bostrom et al., 1990; Davies et al., 1989; Davis & Bostrom, 1993), not many studies have taken place subsequently. This is despite fundamental changes to the configuration of operating systems and application software packages, where most of the interaction with the applications is facilitated by interfaces. This issue is significant because end user apply interfaces while performing activities in their daily tasks. How they use interfaces and which interfaces yield significant improvement in determining training outcomes would provide important insights into training design.

End users

EUC literature provides details of user classification based on users level of interaction with technology. For instance, McLean's (1979) end user categorisation resulted in Data Processing Professionals, DP Users, DP Amateurs and non-DP trained users. The Rockart & Flannery's (1983) categorisation of end users resulted in six categories namely non-programming users, command-level users, end-user programmers, functional support personnel and DP programmers. Cotterman & Kumar (1989) specified a framework for defining and classifying end users and provide taxonomy based on functions performed such as operation, development and control. This taxonomy is referred to as the 'User Cube'. A further discussion on these categories is provided later in the thesis in Chapter 2.

The suitability of EUC categorisation for the modern environment needs to be assessed according to skill complexity in the job (Barker, 1995). Given that there are increasing levels of complexity of EUC activity, end users would experience different expectations of job outcomes due to the use of more skills, greater task identity, greater task significance and more autonomy (Barker, 1995). Therefore, there is a necessity for due consideration required of the various activities performed by users in determining classifications and hence training outcomes (Sein et al., 1993). However, many EUC training studies have arbitrarily selected users and their categorisation and this negligence has caused contradictory results in reporting EUC training outcomes (Davis & Bostrom, 1993).

From a practical perspective, it is apparent that computer training books are targeted at varying levels of users. Moreover, the software learning tools also have recognised the importance of varying levels in user activities such as simple word processing and complex report generation arising from databases. They have begun releasing software to accommodate a range of skill levels in their help files and software manuals. Therefore, the categorisation of users for determining training outcomes in EUC studies should be considered carefully and reflect today's application requirements[2].

User differences

Literature from the field of education has established that the learning habits are unique and individuals follow their own styles (Riding, 1997). This is also true for using interfaces to accomplish a task. While certain users prefer a specific interface, such as icons, others may prefer other interfaces, such as menus. In addition to this, users can understand information given during training in different ways (Schmeck et al., 1977). This understanding will enable them to make their own mental models of the software application structures, which are often necessary for the successful completion of tasks. Therefore, studies in EUC recommend extracting individual differences.

With the advent of new applications, the way information is accessed and understood has changed. The accessibility of information in an online environment varies but many users now have experience with some computing technology. User experience, or existing knowledge about a particular operating platform, their acquired knowledge during training, and these cognitive skills play a crucial role in determining outcomes. Therefore, there is a need to study the individual differences associated with information processing by creating categories of end users.

Training design

Previous studies in EUC training have investigated a number of issues in the training design area and provided useful suggestions. For instance, Guimaraes & Igbaria (1996) established the specific importance of management support and control in EUC training. Nelson et al. (1995) stressed the need for a coherent strategy to link various training elements in order to achieve success in EUC training. Moad (1995) evaluated the benefits of training investment and stressed the need to involve users in the development of training goals and training programs. Harp (1995), while echoing

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[2] In this study, MS Project application is used, which is a good example of today's application software.

similar thoughts, recommended a comprehensive needs assessment to establish skill deficiencies in critical areas before training programs are designed. Barron (1996) highlighted the importance of evaluation of training programs in order to verify the objectives set prior to training were being achieved.

A re-occurring criticism that has emerged from past EUC training studies is the lack of rigor used when evaluating the effectiveness[3] of training design (Davis & Bostrom, 1993; Filipczak & Picard, 1996; Sein et al., 1987). The training settings, materials to support the training, tasks incorporated in training materials, objectives set for measurement purposes and other associated elements appear to have been arbitrary and subjective in EUC studies (Wiebe et al., 1993; Webster, 1996). This has resulted in researchers struggling to explain why a particular result has been obtained. In the current climate, this has been interpreted as a failure to meet the objectives. Possible insights into these problems may be gained by the study of the instructional design in terms of setting up a training framework.

In the scope of this study, training design will focus on the impact of training approaches to determine training outcomes. For instance, choice of an appropriate training approach, the appropriateness of tasks, time allocation etc. will be considered to avoid some of the criticisms found in previous studies. The training design will follow guidelines provided in the instructional design field. Therefore, this study will investigate some of the material available in the instructional domain to establish a more rigorous research framework to facilitate training.

Outcome measurement

Due to considerable difficulties in the methodology of previous research, it is difficult to rely upon the results of EUC available to hand. Therefore, one needs to establish a systematic mechanism for selecting parameters to accurately measure EUC training outcomes. This study intends to do this. Prior studies will be examined in terms of their outcome measurements in order to arrive at an outcome parameter, which will determine EUC training outcomes more accurately. This will then confirm or reject the outcomes of previous studies.

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[3] The term effectiveness is used as a general term here. This should not be confused with "effectiveness" outcome measurement used in this study.

Finally, this study will overcome the problems noted in previous studies by considering an appropriate instrument to categorise users' learning styles; it will follow uniform definitions in describing tasks and their complexity; it will overcome problems of defining levels of users by assessing their skills by a validated instrument; and it will consider appropriate approaches to deliver training prior to the measurement of outcomes. This combination of features will add to the existing body of knowledge in EUC training.

Essentially, the need for the present study has been encapsulated into a number of themes. These include:

- the consideration of modern application interfaces that were not available in EUC ten years ago;
- the development of training materials taking into account suggestions drawn from instructional design theory;
- the accurate determination of individual learning differences in order to explain training outcomes;
- the categorisation of end users based on their prior knowledge and experience which is essential to analyse information processing behaviours;
- the measurement of training outcomes in terms of efficiency, effectiveness and ease of use; and
- the use of theoretical frameworks from the field of education to explain why certain training outcomes will be obtained.

Outline of the thesis

Chapter 2 of this thesis presents a literature review. This chapter traces development in EUC training in detail. It covers the various trends in EUC training studies, the models followed, how the research framework has developed and the outcomes have been obtained. This section provides a synthesis of salient features derived from previous studies in order to develop the specific research methodology for the present study. The literature review comprises eight sections. The first section provides definitions of End User Computing and End Users. The second section recaps the focus areas emerging from the literature. The third section provides details of training outcomes and includes details on quantitative and qualitative approaches used to measure training outcomes. The fourth section provides details of training materials and tasks. The fifth section provides information on individual differences and includes learning styles and cognitive styles. The sixth section focuses on application interfaces. This includes the design of interfaces, their treatment in previous EUC studies and the results obtained and problems encountered with their use. The seventh section in this chapter addresses end user typologies and the categorisation of users in EUC. The last section deals with EUC studies that have investigated management aspects of training.

The research methodology is presented in Chapter 3. The first section covers the refinement of the initial framework depicted in this chapter. This is followed by the research questions and a discussion of research variables. The chapter includes the hypotheses posited for this study. In addition, the chapter includes sections on research method, the development of instruments and the experimental procedure.

The analysis of the quantitative and qualitative information is presented in Chapter 4. Essentially this section will describe how the research design was developed, how the training materials were developed, how the experiment was conducted, the procedure followed to collect data and how the data entry was organised. This chapter will describe the types of analysis conducted to verify the accuracy of data and the various statistical analyses to test hypotheses. The chapter includes sections on reliability estimates, descriptive data analysis and hypothesis testing.

Chapter 5 provides a discussion of the statistical data analysis. The outcomes of the study are explained with supporting materials and the shortfalls of the study are also outlined. This chapter is concluded with a summary of significant findings.

Chapter 6 presents the limitations of the study and future directions. The limitations are discussed in terms of instrument limitations and operational limitations. Chapter 6 concludes with a discussion on future directions in EUC research.

Appendixes 1 through 9 include SPSS outputs, questionnaires used in the study, samples training materials and visual basic code used to extract learning style preferences.

CHAPTER 2 – REVIEW OF LITERATURE

This chapter reviews the literature available in the end user computing (EUC) field since 1980 because this is when the term EUC gained popularity. The purpose of such a literature review is to provide an overall understanding of events that have taken place in EUC research. This is essential because of the extensive range of components of EUC such as interface usage, measurement approaches, training materials, task complexity, motivational aspects, learning styles, outcome measurements, training approaches and other management issues. The literature review will therefore provide a general framework to enable understanding of a number of issues discussed in Chapter 1. The review in this chapter will then lead to the research methodology in Chapter 3.

Preliminary definitions

End User Computing

End User Computing has been defined in a number of ways which reflect the extensive nature of EUC activities. Davis (1985) defines EUC as the ability of users to have control over their own computing needs. The concept of control is also used by Hackathorn (1988) who sees EUC as an information processing activity in which users have personal control over the technology. Barker (1995) extends this definition by including access to computer resources, data and support services. This can be compared to Cronan & Douglas' (1990) broad definition which includes development, interaction and the utilization of application systems. The definition provided by Brancheau & Wetherbe (1985) includes the optional development of computer applications and models by personnel outside the Management Information Systems (MIS) department, while Benjamin (1982) defines EUC to include all applications developed outside the data processing or the formal Information Systems (IS) department. The definition provided by Hutchinson & Sawyer (1996) refers to EUC as an end user's decision to adopt the software, their extent of usage and subsequent effectiveness in using the software which is dependent upon factors such as available interfaces, training, readability of training materials, motivation, organizational support and management.

End User

The term "end user" has been defined in a number of ways. The definition provided by Benjamin (1982) defines an end user as

> A person without much technical knowledge of computers but who uses computers to perform professional or personal tasks, enhance learning, or have fun. The end user is not necessarily a computer expert and may never need to become one. Most companies, for example, prefer to train their employees in the specific computer uses applicable to their job and these applications may never require the user to have much technical knowledge (p. 12).

Hutchinson & Sawyer's (1996) definition refers to end users as people

> ... not usually technically trained computer professionals such as computer programmers or operators. Rather, they are non-technically oriented people who gain some benefit from using computers in their personal work or lives (p. 26).

While both definitions refer to training, Benjamin's definition is specific to employment related training. This type of training has its focus on skills development and is dependent upon specific industry settings. Hutchinson & Sawyer's definition, on the other hand, refers to the generic use of computers. Therefore, Hutchinson & Sawyer's definition is suitable for this study because this study examines the influences of application interfaces, training approaches and prior knowledge of non-computing personnel in determining training outcomes.

Background Theory on EUC Training and Aspects of Learning Relating to EUC Training

Encompassed under the investigation of EUC have been a range of studies, such as those investigating the design of training programs (Sein et al., 1993), guarantee for success (Davis & Bostrom, 1993), specific outcomes and the measurement of these outcomes (Bostrom et al., 1990), how to classify end users (Rockart & Flannery, 1983). Other studies have investigated training materials (Carrol, 1984; Carrol & Mazur, 1986; Olfman & Bostrom, 1991; Olfman & Mandviwalla, 1994), where the focus has been on the sequencing, complexity, level of difficulty, content, information cues and the cognitive demand of these materials. Further research has been directed at users' preferred learning and cognitive styles and the way they process information (Bostrom et al., 1990; Sein & Bostrom, 1989). Yet others have studied management and controls in EUC including costs, return on investment, need for corporate participation, achievement of objectives and resolving issues arising out of incompetence (Filipczak & Picard, 1996; Fitzgerald & Cater Steel, 1995; Harp, 1995).

An initial examination of previous studies indicates that it is possible to fit EUC studies into one of the three broad categories based on the issues investigated and mentioned in Chapter 1. These three broad categiroes are (i) end users and their general problems with EUC training; (ii) problems associated with training design, training approaches, outcome measurement and controls exercised during training; and (iii) the learning and cognitive aspects of information processing associated with end users.

As far as the general problems associated with end users are concerned, EUC studies indicate that EUC training suffers from weaknesses because of users' relative inexperience in making critical decisions when using applications (Barron, 1996; Douglas & Moran, 1982); users' inability to recall and use command syntax (Borgman, 1986; Davis & Bostrom, 1993; Fitzgerald & Cater Steel, 1995; Michard, 1982); users' difficulties in applying software packages to specific tasks (Bowman et al., 1994; Carrol, 1984; Filipczak & Picard, 1996; Nelson et al., 1995); understanding how to classify users based on their ability to perform a job (Rockart & Flannery, 1983) and user's inability in understanding training materials because of technical complexity and confusion about how to recover from errors (Carrol & Mazur, 1986; Chaney & Wills, 1995).

Studies that have examined user levels indicate that relative inexperience often prompts users to take inappropriate actions when using applications (Carrol & Mazur, 1986; Olfman & Mandviwalla, 1995). For example, inexperienced users in spreadsheet applications may not be aware that when a column or row in a spreadsheet is deleted by accident, the reference to another cell in the spreadsheet can also disappear without warning and this can generate erroneous data at a later point.

Further, studies by Davis & Bostrom (1993) and Sein et al. (1993) have also found that users are not always capable of recalling and using command syntax and highlight the need to understand user characteristics. These studies point out that users prefer to see information in different forms such as images and text strings and hence instructions and training materials should reflect these differences. Other studies (Mayer et al., 1995; Olfman & Bostrom, 1991) have also pointed out that the inherent complexities of applications and associated training instructions result in users not being able to recover from errors.

As far as the problems associated with training design are concerned, research indicates that EUC training suffers from a lack of consideration given to training design (Carrol, 1984; Craig & Beck, 1993; Fitzgerald & Cater Steel, 1995); a lack of front-end analysis needed in establishing training needs which subsequently leads to inappropriate needs assessment (Marsick, 1988; Nelson et al., 1995; Webster, 1996); improper use of tasks and complexity of tasks (Carrol & Rosson, 1995; Craig & Beck, 1993; Mayer, 1981); problems with inappropriate evaluation methods (Barron, 1996; Black, 1995; Cheney et al., 1986); and the suitability of measurements used in determining training outcomes (Brancheau & Wetherbe, 1990; Chrisman & Beccue, 1990; Lee et al., 1995).

It can be inferred that these studies have examined sufficient aspects of training design to indicate that the area of training design in EUC needs more work and these studies have found that there is a need to develop a front-end analysis to determine training needs accurately. This determination would then establish training objectives. The training objectives would lead to training evaluation. In between training objectives and evaluation, issues relating to instructions, tasks, complexity of tasks, how to sequence these tasks and how to deliver these tasks should be considered. Finally, the production of training materials should involve the combination of activities mentioned. Thus, prior studies have recognized the importance of activities and have concluded that these activities influence training outcomes. In other words, 'training design' plays a major role in determining training outcomes.

While user problems and EUC training design problems have been endorsed by a number of studies in EUC (Fitzgerald & Cater Steel, 1995; Guimaraes & Igbaria, 1996; Holton & Bailey, 1995), the problems associated with learning and cognition have been identified only in certain EUC studies (Davis & Bostrom, 1993; Holton & Bailey, 1995; Mayer, 1981; Olfman & Mandviwalla, 1995; Sefton, 1993; Sein et al., 1993). These studies highlight the need to categorise end users based on their learning style preferences (Davis & Bostrom, 1993); the need to understand how end users process information as a result of their cognitive traits (Mayer, 1981; Olfman & Mandviwalla, 1995); the need to recognise cognitive traits in order to understand motivation, satisfaction and ease of use (Sein et al., 1993); and the importance of learning style preferences for information processing sequences and the development of associated mental models to understand the software (Holton & Bailey, 1995). Information derived from investigating aspects of learning and cognition in EUC studies may be useful in the production of training tasks, training materials, sequencing of tasks and other aspects related to training design. In addition general understanding of how information is processed while accomplishing tasks would assist EUC training in terms of structuring the training design. Hence the need to study learning style preferences.

Overall, due to the fact that only few EUC studies have investigated aspects of learning and cognition, it appears that EUC research has not given full attention to aspects of learning and cognition. While certain studies have stressed the need to study learning and cognition, the vast majority of research has failed to pay any attention to these two aspects. Studies that have taken learning and/or cognition into account have emphasised the need for accommodating user style preferences and their influence on information processing. Evidence can also be found of some studies that have considered cognitive aspects of information processing to explain their outcomes (See Davis & Bostrom (1993) for a discussion on this).

Therefore, it can be inferred from a brief overview of the literature that future research in EUC should also focus on the role of learning and cognition in delivering efficiency and effectiveness outcomes where the effectiveness factor should capture users' ability to understand and correctly apply the information provided during training when completing specific tasks, whereas, the efficiency factor should capture users' ability to accomplish tasks in a given time span as a result of available skills or knowledge. For instance, Sein & Bostrom (1989) argue for the proper analysis of user characteristics such as individual learning preferences, before commencement of training, in order to construct attainable objectives that can lead to effectiveness and efficiency.

Further, most previous studies such as Davis (1985) have focused on one type of end user, namely beginners. However, studies (Cotterman & Kumar, 1989; Davies et al., 1989) have indicated the need for categorising users based on their job functions. Further, Some of the assumptions made in previous EUC studies were based on the training model of the 1960s where paper and pencil were used as tools whereas the current classroom approach involved interaction with the instructor. On the other hand, when computers are used as a tool for learning, the interaction is with the interfaces available in the application, in addition to the instructor and the aspects of computer interfaces and their usage assume importance in current EUC studies. Therefore, it can be assumed that the validity of EUC training research based on the training models of 1960s is questionable[4] in the current climate.

While previous studies have provided valuable information on how to train end users, little information is provided on the combined influences of interfaces, training approaches, training materials and learning preferences. This has led to the criticism that the outcomes reported by some prior studies are not conclusive because of lack of detail. This has resulted in Barron (1996) stressing the need for the accurate identification and definition of training needs and scope for designing training programs to achieve success.

Therefore, it appears that previous studies in EUC training have not addressed in depth the form in which different levels of users recognise information, how information is processed while completing a task, how technical information is comprehended while training, and how the learning is utilised after training. While studies such as Sein et al. (1993) and Olfman & Mandviwalla (1995) have highlighted the need to investigate the education domain to understand the learning and cognitive aspects of EUC training, very little evidence can be found to ascertain that research in this area has actually done so. Therefore, there is a need to understand how end users use interfaces while accomplishing tasks, how the interfaces assist users to complete a given task, how training materials can help users to understand and to remember various operational sequences and finally how all these can be achieved in an efficient and effective manner.

While a range of activities are considered in EUC, the scope of this study is restricted to training outcomes arising from the use of training materials on an application software by end users. This is because end users 'learn by doing'[5] in the sense that software applications are mastered by end users by actually performing

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[4] see Ruble & Stout (1993) questioning of the statistical significance of the Bostrom et al. (1990) framework and Bohlen & Ferrat (1997) suggesting that the framework used by Davies et al. (1989) and Davis & Bostrom (1993) were unrealistic with respect to their training methods.

[5] The concept 'learn by doing' has been briefly introduced in Chapter 1. Hutchinson's definition also indicates this.

activities using them (Kirton, 1974). Hutchinson & Sawyer's definition provided earlier, mentions this as "people who gain some benefit from using computers". End users typically undergo training to understand how to use computers and associated software applications. Training helps them to understand the commands and operations of software applications and the interfaces help them to interact with applications. In other words, the interaction between the application software and the users is facilitated via the interfaces available in the software. This combination – interfaces, training and users knowledge, either acquired through training or through prior experience determine outcomes. The literature is further reviewed with this scope in mind.

Categories of End Users

Despite the growth of EUC, opinions still diverge as to the constructs used to describe categories of end users. There are few typologies available to categorise end users. McLean's (1979) classification is based on user's data processing activities. Rockart & Flannery's (1983) typology identifies end users based on the activity sophistication. This typology is based on the type of activity, such as wordprocessing, performed by users. Davis' (1985) typology identifies users based on their usage sophistication. This typology is based on reasons for the use of computer system i.e. for wordprocessing purposes without specific attention paid to applications. Rivard & Huff's (1988) typology categorises users based on their application sophistication. Cotterman & Kumar's (1989) typology categorises users based on their interaction with computer based information systems in three dimensions resulting in a user cube. A brief discussion is provided below to introduce these typologies. Once these typologies are introduced, the consideration of users in EUC training studies is discussed.

McLean's Classification

McLean's (1979) broader classification of end users, based on the information provided, consisted of four categories, data processing professionals (DPP), data processing users (DPU), data processing amateurs (DPA), non-data processing trained users (NTU). The DPP wrote programming code for others' use. DP Users were further divided into DPA and NTU based on the programming code was used. The

DPA wrote programming code for their own use. NTU used programming code written by others. According to Cotterman & Kumar (1989), McLean introduced the concept of DP producers who produce information for the purpose of interaction with the system. The classification may not apply to the current climate because end users now perform a variety of functions such as writing macros available in applications.

Rockart and Flannery's typology

While McLean introduced the concept of user classification based on information produced by users, the categories developed by Rockart & Flannery (1983) appear to be the first attempt in defining end users based on their activities. This categorisation defines six levels of end users. *Non-programming end users* utilise icon or menu-based applications developed by others. Typically, they use application software in their normal daily activities. These end users are not conversant with various forms of dialogue and pseudo-programming languages such as 3GLs or 4GLs. *Command level end users* can manipulate available information with the help of non-procedural query languages. The reference to non-procedural query languages is important as this highlights the lack of discipline followed by these users in terms of languages. These users use these query languages to produce reports. They may have functional knowledge of report generators, however, such knowledge is generally limited. *End user programmers* are conversant with programming languages. They develop applications for their own use or for other end users' use. The main difference between end user programmers and information systems (IS) programmers is the concept of a structured team. The end user programmers develop applications without following the principles of "developing a system". Most often these programmers develop ad-hoc systems and systems auditors may not audit these systems. *Functional support end users* develop applications in their functional area. They differ from end user programmers because of their knowledge in the domain area where they are working. They are sophisticated in their access to resources and are usually involved in decision making. They develop applications to support the various functional elements of their domain area. *Information centre support end users* are computing professionals from the IS area but are allocated to an end user support role. For example, they may provide training to other users. Usually these end users are allocated to an administrative department to provide a range of support to users in that department. *Data processing programmers* use fourth generation languages to develop tools for other end users. They follow the traditional development methodology and develop systems for other users. However, while such systems are developed, they will employ fourth generation languages because the systems will be maintained later by the end user programmers. The maintenance component in a system's life cycle forces them to use fourth generation languages, which are easy for others to understand.

Davis' typology

Davis' (1985) typology is based on usage sophistication. This typology categorises end users into three categories. *Indirect users* act as intermediaries to applications developed by others. They have comprehensive functional knowledge but possess no application development techniques. So, they act as human "interfaces" in explaining the problem while applications are developed. These users have derived their knowledge by working in the domain area. *Direct users* use the online and offline applications developed by others. Through their usage they gain comprehensive knowledge of working versions of the applications in their working domain, although they may not possess functional knowledge[6]. *Autonomous users* develop applications for their personal use or for group use. They act independently in their development.

Rivard & Huff's typology

The typology developed by Rivard & Huff (1988) is based on application sophistication in an organisational setting. The three categories created include opportunity seekers, staff analysts and micro-IS department. *Opportunity seekers* develop applications using "macros" and other tools available for their own use in an applications environment. These users are familiar with software application concepts and they are able to perform "what if analysis" using applications such as spreadsheets. However, these end users do not test their applications and the component modules developed by them may not be reliable. *Staff analysts* develop

[6] Functional knowledge refers to knowledge of system functions while conducting a task. This knowledge involves knowledge of files for processing, control sequences, startup functions of specific modules etc. On the other hand, working knowledge involves how a specific task is conducted manually, for example how a financial report was generated using a spreadsheet software and how computer reports are processed for manual cross checking etc.

modules to solve organisational problems using a technique called 'prototyping' or they provide information to other users. Once the problem is solved, the modules are discarded or developed using formal development methodologies. These users provide documentation for others to use the application, but in most cases, there is no documentation generated as the module is developed to solve a specific user problem rather than an organisational problem. Most often these users have limited access to organisational data. *Micro-IS department* end users have extensive computing skills. They develop applications for others in their departments and hold special positions in their departments because of their expertise. These users have a good level of access and control over the department's data and other resources.

Cotterman & Kumar's User Cube

Cotterman & Kumar (1989) classified users based on their interaction with the computer-based information systems as a consumer or producer of information. The classification by Cotterman & Kumar (1989) produced a user cube with operation, development and control as three axes. Operation in the user cube included systems operations including initiation, termination, monitoring and the execution of manual tasks necessary for the operations of a computer based information systems. Development in the user cube refers to the performance of tasks during the systems development process. The development includes various phases of the systems development such as requirements, design and implementation. Control in the cube refers to the activities needed to develop and operate the computer based information systems.

Cotterman & Kumar (1989) used a unit cube concept to map the end users with other typologies found in the EUC literature of their time. For instance, they mapped the indirect end users of a Codasyl categorisation with their cube concept at node (0,0,0). Similarly mapping of end users from other classifications such as McLean could also be found in Cotterman & Kumar's (1989) user cube.

Barker's Classification

Barker (1995) discussed end user classification based on job characteristics such as experienced meaningfulness of work, responsibility for work outcomes and knowledge of work results. The characteristics, according to Barker (1995) arise from five specific factors of a job, namely, skill variety, task identity, task significance, autonomy in the job and feedback about result from work efforts. Skill variety is the degree to which the job requires different talents from users. Task identity is the degree to which the job requires the completion of a whole piece of work from start to finish. Task significance refers to the degree to which the job has an impact on others in the workplace or outside the organisation. Autonomy is the degree of freedom given to the user to exercise control on the job. Feedback is the amount of information the job provides about work effectiveness. Barker (1995) argues that these five factors enable end users to experience higher degree of job outcomes including motivation and satisfaction.

A further loose classification can be extracted from EUC literature. This classification is based on experience and includes basic end users, intermediate end users and advanced end users (Carrol & Mazur, 1986). Few studies in EUC have referred to this categorisation (Bostrom et al., 1990; Carrol & Mazur, 1986; Davis & Bostrom, 1993; Sein et al., 1987). This classification is generally ascertained by administering a reliable instrument to extract users' level of experience and prior knowledge. It is argued that users' prior knowledge aids in understanding an application and helps in developing a mental model. These studies further argue that prior knowledge helps users to solve tasks in novel situations. However, it should be noted that this classification of users has often been based on self-reported information which means that the categorisation is not necessarily reliable.

In general, despite the availability of EUC classification typologies, there appears to be no uniform guidelines for the selection of subjects in EUC training studies. For instance, Davis & Bostrom (1993) considered users who reported that they had no knowledge of operating system commands and were selected on the basis of having had little or no previous experience with personal computers. In the study conducted by Barki et al. (1993), users were selected based on the fact that they had had either hands-on experience with computers or had made use of some output produced by a computer system. The users ranged from managers to secretaries. The study by Blili et al. (1998) considered users who were involved with EUC activities. These were non-programming end users, command level end users and programmers, who were categorized based on their computing utlilisation and hence the variety of end users.

Olfman & Mandviwalla (1995) used students from a tertiary background for his study. They were enrolled in an information systems course and all had previous computing experience, ranging from some basic commands to sophisticated programming. The students self-reported their average computing experience. Marcolin et al. (1997) involved users who had college training, held either a technical or a professional position, and used computers at least once a day. These users were drawn from the general operations, accounting, marketing, human resources and engineering sections of an organization.

Bohlen & Ferrat (1997) used tertiary students who had little or no previous experience with word processing software applications, which were the focus of the experiment. Bostrom et al.'s (1990) study involved tertiary students. These students were first year introductory computing students in a business course and had basic knowledge of an operating system (VAX), but were not highly experienced.

Brancheau & Wetherbe (1990) recruited users familiar with spreadsheet concepts in their study. They included managers, supervisors, technicians, professionals, clerks and secretaries in a number of organizations in the US. However, there is no evidence that these users formed a homogeneous group in terms of their qualifications or experience.

Sein et al. (1993) used students from the introductory computing course of a Business program for his study. These students had acquired fundamental computing concepts in their course but prior to enrolment they did not possess any computing experience.

Therefore, while typologies to classify users exist, it appears that studies in EUC training have seldom considered these typologies. One reason appears to be that these typologies are applicable to organisational settings and not to study measurement of training outcomes. However, that selection of users could incorporate some aspects of these typologies. For instance, Rockart & Flannery's non-programming end users are comparable to users in many EUC training studies. But, despite this accidental similarity, some of the studies in EUC training have selected users based on their knowledge alone and have ignored the fact that knowledge is dependent upon experience (Bohlen & Ferrat, 1997; Bostrom et al., 1990; Sein et al., 1993). While these studies have argued that prior knowledge (as a result of experience) is essential in problem solving in novel situations, in respect of the studies reviewed in the thesis, studies in EUC appear to have omitted to include the experience component[7] while categorising end users. Finally, the users selected in EUC studies do not form a homogenous group and hence the results reported by these studies were not always comparable. This study will aim to alleviate this problem by properly classifying users based on both knowledge and experience.

Key Issues in EUC Training

In the past decade, key issues in EUC training centered on training and its outcomes and studies have dealt with issues such as interface usage (Bostrom et al., 1990; Davis & Bostrom, 1993); training approaches (Carrol & Rosson, 1995; Olfman & Bostrom, 1991); learning styles (Davis & Bostrom, 1993; Sein et al., 1993); motivational aspects (Simon et al., 1996) and learning success (Nelson et al., 1995). These aspects include investigation such as the construction of training materials (Olfman & Mandviwalla, 1995); the construction of tasks (Campbell, 1991); sequencing of tasks and incorporating these tasks in different training approaches (Mayer, 1981); motivational aspects such as why a specific software application is found to be easy (Carrol et al., 1987); control and management of training programs (Fitzgerald & Cater Steel, 1995); and to some extent how information is processed in order to accomplish given tasks (Davis & Bostrom, 1993).

These studies have measured training outcomes in terms of number of keystrokes used to complete a given task; percentage of errors; scores allocated to tasks; accuracy; time taken to complete given tasks; satisfaction and ease of use. Past research in EUC training can therefore be classified into studies that have quantitatively measured training outcomes where scoring schemes and/or measurement of time components have been used and studies that have subjectively measured training outcomes where opinion surveys have been used to extract user opinions. These two types are referred to as quantitative measurement and subjective measurement in this thesis.

[7] Studies reviewed provided limited information as to how the experience component is considered while considering subjects for training and experiment.

Quantitative measurement of training outcomes and problems associated with this measurement in previous EUC studies

EUC studies that have measured training outcomes quantitatively have presented their results in terms of scores, accuracy, and errors (Barker, 1995; Olfman & Mandviwalla, 1995). For instance, scores are traditionally measured in terms of keystrokes while using application software packages (Davis & Bostrom, 1993). Accuracy is measured as a composite total of keystrokes and the errors (Bohlen & Ferrat, 1997).

Score

Various EUC studies have used quantitative measures of outcomes to evaluate hands-on training exercises. For instance, training outcomes have been measured in terms of scores allocated to the various steps involved in completing a set of hands-on tasks based on the users' understanding of training instructions (Davies et al., 1989). Bostrom et al. (1990) expanded the study by Davies et al. to include the characteristics of target system, training approaches and characteristics of trainees in order to measure users' interaction with the system. Scores were allocated for users' success in a hands-on experiment conducted in a laboratory setting. A further similar study is that of Davis & Bostrom (1993) which measured the outcome of two types of training (instruction and exploration) but omitted the trainee characteristics included in the Bostrom et al.'s study. Davis retained the number of tasks but modified the target system component to include an additional interface – direct manipulation to reflect the operating system functions at that time. The operating system in use was based on either the Apple Macintosh or the DOS. Use of the Apple Macintosh system is facilitated by icons representing the interface. However, not all functions are represented by icons, so users need to type in commands using a keyboard entry and hence the inclusion of two types of interface in the study. Thus, while Bostrom et al. evaluated training outcomes based on scores alone, Davis included an accuracy component, which is discussed later.

While Bostrom et al.'s (1990) study concluded that interfaces play a crucial role in determining training outcomes, Davis & Bostrom (1993) reported that one specific type of interface – direct manipulation interface – yielded better performance for novice users. Additionally, Davis & Bostrom reported that training approaches were not significant in determining training outcomes.

Sein et al. (1993) measured subjects' understanding through interactions with the system using software applications such as electronic mail (email), wordprocessing and spreadsheet under two training types - analogical and abstract. The analogical training represented the computer system in terms of another system and the abstract training is the synthetic representation of the computer system. For instance, in the analogical training type, a filing cabinet and its operations are used to represent file operations such as move, trash and copy in a computing environment. Both analogical and abstract systems help to develop mental models of the computer system.

Sein et al. reported integrated findings from five studies[8] measuring users' knowledge of software. The first study involved two sessions of training with an e-mail application using training manuals followed by a hands-on experiment to measure user's ability to manipulate email messages stored in the system and a comprehension task to test users' understanding of the system. Each user's interaction in the hands-on tasks was recorded using an online log. However, Sein et al. felt that this study was not well organised and expanded it in order to generate more robust results. This resulted in a second study conducted in the same year and consisting of eleven training sessions where the earlier comprehension test was modified to include questions asking subjects' to determine the system's response to a series of commands.

The third study consisted of a financial planning software application and subjects were provided with training to solve a practice task. The main difference in this study was the absence of training materials. The software was demonstrated and instructions were displayed via examples using a overhead projector. The measurement involved a practical budget building exercise recorded using on-line logs, to assess correctness and completeness, followed by a comprehension test. Little evidence is available regarding the nature of the comprehension questions.

The fourth study consisted of a Lotus 1-2-3 application and 12 training sessions were provided to managerial staff in order to develop users' ability in performing hands-on tasks. Users were then asked to develop a financial budget

[8] The five studies were reported in one journal article but there is limited information available on just when each study was carried out. It is reported that results from one study were used to refine the next study and the term 'integrated findings of five studies' is used by Sein et al. when discussing this research.

using the spreadsheet application and the measurement of the training outcomes involving the correct identification of variables, relationships between variables, formulae and syntactic accuracy. A solution template was prepared for this purpose and the users' responses were matched with this template in order to arrive at a score.

Sein et al.'s last and fifth study involved measuring users' ability to understand the Apple Macintosh and DOS operating systems for which training materials and necessary instructions were supplied. The assessment consisted of tasks that involved the manipulation of files and directories. This was followed by a comprehension test which consisted of four two-part problems. Part one of each problem asked users to examine a series of commands and then supply the output that would result from them and part two asked each user to explain each command in the series. As in the previous cases, a solution template was developed to determine scores.

As a result of these five studies, Sein et al. reported that interfaces and conceptual models play a determinant role in training outcomes. While user interactions with the system were not statistically significant in the integrated study, Sein et al. noted that there is support for the role played by interfaces in determining learning outcomes. He also found that direct manipulation interfaces were superior to command interfaces in terms of performance because of the more comprehensible representation of the system provided by these interfaces.

Olfman & Bostrom (1991) measured training outcomes via a scoring scheme which was based on hands-on tasks completed using pencil and paper[9] to demonstrate understanding of Lotus 1-2-3 Spreadsheet application software. The rationale for the pencil-and-paper model was based on comments received when subjects expressed their inability to complete the tasks using computers during a pilot study. Understanding was measured in terms of language understanding and problem understanding. The measurement of language understanding includes knowledge of syntax and functions of the software which were measured using quiz scores. The quiz consisted of short answer questions that were designed to test knowledge of

[9] This aspect is mentioned here to denote the ways in which hands-on tasks are handled in EUC studies. However, this study will use a computer for this purpose, as discussed in the Research Methodology chapter.

software architecture, syntax and functions as covered in the training. The quiz had no time limit.

Problem understanding involved measuring users' knowledge of how to utilize the software to solve a particular problem and was measured using task scores. Each task consisted of one short problem designed to test simple model building in a spreadsheet environment which was saved onto a floppy diskette. Olfman & Bostrom (1991) concluded that previous experience helped subjects to understand tasks better and also resulted in better performance.

A second study conducted by Olfman & Mandviwalla (1994) examined the training outcomes resulting from two different software training manuals using a groupware software package. Olfman & Madviwalla measured subjects' understanding of the software using written questions and established that training manuals should consist of task sequencing, appropriate choice of tasks and associated text elaboration to properly introduce conceptual information in software training. Olfman & Mandviwalla (1994) found little to no support for the previously held belief that rich conceptualisation and usage information would positively affect understanding of software applications. While Olfman & Mandviwalla measured subject's understanding of the software using a scoring scheme, it appears that partial credit was given for some answers. However, there was no explanation as to how this partial credit was determined and hence appears to not be uniform. In other words, when a subject could have scored a partial credit for an incomplete answer, there is no guarantee that another subject would also have scored partial credit for a similar answer. Scores were also reported in terms of percentages and this made it difficult to follow how subjects' were allocated with raw scores.

The training outcome measurement used in Bohlen & Ferrat (1997) research consisted of test scores, practicum scores and assignment scores. Subjects included 110 voluntary tertiary students enrolled in an introductory computing course. A word processing environment (WordPerfect 5.1) was simulated by another software application in order to determine the accuracy of user actions in accomplishing tasks. Subjects were given training sessions to complete the tasks and the potential range of this score was measured by a special software program called the "Judd Test"[10]. The study found that method of instruction (practicum or lecture) has an impact on training outcomes.

Accuracy

In addition to scores, EUC studies have used the notion of accuracy to determine the success of training outcomes. A combination of score and errors determined accuracy. For instance, in Carrol & Mazur's (1986) study, accuracy was measured in terms of errors committed in word processing tasks and the error taxonomy included mechanical errors, manual errors, menu errors and typing errors. Users' actions were compared using a solution template to compute the number of errors.

Bostrom et al.'s (1990) study, on the other hand, measured accuracy by manually analysing the solution provided by users. Sein et al. (1993) in their integrated study of five experiments measured accuracy by manually matching users' actions with a solution template for correctness. Bohlen & Ferrat (1997) measured training outcomes in terms of accuracy using the "Judd Test", which simulated a word processing environment. The Judd Test measures the accuracy of software skills demonstrated by users while using a software application.

Time

Many EUC studies have used a time component to measure training outcomes. Two approaches – the self-reported survey and the automated computing log – have been used. While the automated logs have been accepted as reliable, self-reported surveys have been used as an alternative when there was difficulty in implementing automated logs.

In calculating the time taken by users to interact with the system, Bostrom et al. (1990) used a computer log showing time recordings. Sein et al. (1993) used a similar computer generated session log for certain tasks in a hands-on exercise task. The subjects in Sein et al.'s study were asked to perform one task at a time so that this

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[10] Judd Test is a computer program to measure subject's knowledge in using WordPerfect software application. This program was designed based on the US federal guidelines in measuring understanding of a given task.

measurement could be isolated for each task, compared to the combined time noted by Bostrom et al.

Davis & Bostrom (1993)[11], on the other hand, asked subjects to notify them when they had completed the hands-on exercise for which a maximum of 30 minutes was allowed. While Davis & Bostrom did not place any restriction on the time limit for individual tasks, Sein et al. limited these tasks to 3 minutes. Blili et al. (1998) used a time component to assess user computer usage which was reported in number of hours per day.

Carrol & Mazur (1986) used a 20 minute limit for subjects to boot the system using system diskettes, load application diskettes to perform tasks and to get to the typing area and to recover from any errors while doing these tasks. This approach facilitated to distinguish between the 'system state' and the 'training state'. Carrol & Mazur followed this approach in order to study only training related information and not how users behaved while starting a system because this was not part of the training provided by Carrol & Mazur . However, Carrol & Mazur considered the influence of initial preparedness on the experiment and mental state of subjects and hence provided this 30 seconds limit to recover from any errors committed by users. This exercise has led to an error taxonomy developed by Carrol & Mazur which included a list of the common errors committed by users and the amount of time to recover from errors while starting a system in a DOS environment which was used for the study. This error taxonomy was not found in other studies and appears to be unique in end user studies.

Self-reported time was included as an outcome measure by Olfman & Mandviwalla (1994), however, Olfman & Mandviwalla do mention the possibility of inaccuracies because of manual errors in the reporting process. While using a computer to capture 'time' information, it is possible to accurately measure the time because of the computer clock. However, when users report time, they may not be precise and this may introduce inaccuracies in the reporting process. Further, if it is a computer clock based time recording, it is possible to revise the log to ascertain the accuracy, which is not possible in a self-reported time report. Nonetheless, Olfman &

[11] It is worth noting that the hands-on tasks consisted of individual sub-tasks. While Davis measured time for the total hands-on tasks, Sein et al. measured time for individual sub-tasks.

Mandviwalla used the method of self-reported time because it was the best alternative available at that time for machine-based methods.

Bohlen & Ferrat (1997) used self-reported time for assignments and the Judd test for practicum tasks to obtain the time taken to complete tasks. For example, subject's recorded their working time to complete the five tasks in the assignment on a paper form. The Judd Test was used to determine the time taken to complete each task for the practicum component in the study.

The training outcomes studied by Cronan & Douglas (1990) were expressed in terms of users' self-reported times. While Cronan & Douglas's study provides little information about the nature of tasks involved in the experiment, the study indicates that the time component was applied to the development of applications rather than to the time taken to complete a given task. In the proposed study, the time component will be used to measure only given tasks and not the development activity because development includes analysis, design, programming, testing and implementation as end users are not usually involved in these traditional computer science development cycle.

It can be seen from the above review that while some studies have used time measurements on the total experiments (where individual tasks are not distinguished), other studies have used a time component with individual tasks clearly distinguished within the experiment. Individual tasks have been distinguished in order to avoid measurement of the time spent in switching from one task to another, so as to arrive at a more accurate measure of time. Some studies have used both self-reported surveys and automated logs for capturing the time component in the same experiment. One study has used a composite of minimum of strokes and time, to derive a measure of efficiency, and, as such, two completely different factors have been integrated to determine efficiency (Bohlen & Ferrat, 1997). This is not entirely desirable. For instance, if somebody reports the sum of height and weight to represent an outcome of a person's characteristic, despite the acceptable mathematical operation, the result would be meaningless. Bohlen & Ferrat's study, for example has used a composite of minimum keystrokes and time in measuring outcomes which is of questionable reliability.

Validity of quantitative measures used in previous studies

The quantitative outcome measurements outlined above include a range of methods for EUC skills assessment. However, the measurement schemes followed in Davies et al. (1989), Bostrom et al. (1990) and Davis & Bostrom (1993) are flawed for two reasons. First, the scores allocated to users' work were open to subjectivity. Thus, while these studies reveal that independent reviewers assessed users' work and allocated scores they were not guided by a solution template. The second flaw was in the allocation of partial scores. While the studies mention that the scores were allocated partially, the circumstances for this are not fully described. Again, there is some risk of subjectivity. Additionally, users were provided with instructions developed in an ad-hoc fashion i.e., without any structured approach. For instance, the instructions developed to perform similar tasks were not closely matched in these studies. Thus, while Davis & Bostrom used instructions such as "Select a file by clicking on it once", Bostrom et al. used different instructions for a similar task. Additionally, the tasks varied in their complexity. These shortcomings have also been identified by Ruble & Stout (1993).

While Sein et al. (1993) produced a solution template to evaluate users' interaction with the system, they failed to control the experiments uniformly. For instance, training manuals were provided for only certain components of the experiment. While justification for this approach was the use of the same subjects, there was possibility of bias as subjects learn the software functions when moving from one study to another. Another aspect is the use of online logs to avoid the subjective bias introduced in the allocation of scores and the determination of errors. It should also be noted that Sein et al. were careful in using an online log and not a 'floppy diskette' to track users' interaction with the system as online logs record most printable actions compared with writing to a diskette. Olfman & Mandviwalla (1994) followed a similar approach by using an online log and called the log an "audit file".

While Olfman & Mandviwalla's (1994) study included explicit tasks, the scoring scheme for the quiz was problematic. Olfman & Mandviwala assigned 9.5 points for 9 questions and provided no details about the allocation of these points. Additionally, the scoring was arbitrary with the allocation of scores across the six basic tasks which were not clearly defined. Another problem was the allocation of additional bonus points. The circumstances in which these were allocated are not given in the study. Further, the study mentions that the instructors assessed the tasks for problem understanding giving an impression that there was no independent assessment. The same flaw was encountered in Bohlen & Ferrat (1997) study in terms of assignment scores. However, the use of a computer-based program[12] would have generated valid results for practicum scores in Bohlen & Ferrat's study.

The studies reviewed have a common problem, that is, where training outcomes were assessed without any valid assessment guidelines, subjectivity could have been introduced. It seems that this subjectivity component has not been taken into account. The failure to provide any guidelines could mean disparity in the allocation of scores, introducing a general flaw in the scoring scheme. While it is not possible to completely eliminate subjectivity, it is possible to minimise it. Assessment scoring schemes and other measurement schemes by peers can do this. In addition, there are guidelines available in instructional design on how evaluations can be conducted in assessing skills and by following these guidelines, subjectivity can be minimised.

[12] This study will follow this approach of using a computer based tool in recording the operations performed by subjects to determine scores and errors.

Subjective measurement of training outcomes and problems associated with this measurement in previous EUC studies

EUC studies have measured training outcomes subjectively in terms of attitudes and motivation for using a system after training. While attitudes provide an opinion, motivation provides reasons for actions based upon such an opinion (Sein et al., 1999). For example, a user may have the attitude 'I don't like this software package', the motivation behind such an attitude may be 'the system is difficult to use'. Both attitude and motivation outcomes are traditionally measured using an opinion survey or a questionnaire. For example, Bostrom et al. (1990) measured users' attitudes towards a system with a five point Likert scale. As a consequence, Bostrom et al. suggested that positive attitudes enhanced understanding and hence use of the system. Barki et al. (1993) measured user attitudes using a questionnaire that consisted of 'yes' or 'no' type responses. Olfman & Mandviwalla (1994) used a seven-point Likert scale to measure user attitudes towards a computer system. However, while measuring users' attitudes, the instruments extracted only general opinions about the system.

On the other hand, EUC studies have considered motivation in terms of ease of use, satisfaction, involvement and usefulness. Instruments have measured components of motivation, such as satisfaction. While measuring such motivational aspects, users were asked to fill in a survey form or a questionnaire to express their opinions with respect to a specific motivational item, such as satisfaction, as a result of the training provided. Davis & Bostrom (1993) measured the perceived ease of using a system with a five point Likert scale, with regard to the learning of a specific software package and to users' expectations in terms of becoming skillful in its use. Davis & Bostrom (1993) found that perceived ease of use is positively correlated with training outcomes. Training outcomes have been measured via a motivational score in Olfman & Mandviwalla's (1995) study, which consisted of perceived usefulness, ease of use and intention to use the software. While perceived usefulness and ease of use consisted of four-question items on a seven-point Likert scale, intention was measured with two items on the seven-point Likert scale. The items were averaged in order to report a standardised score[13]. Olfman & Mandviwalla (1995) did not find any significant difference in perceived usefulness before or after training in using spreadsheet software. But ease of use and intention were positively correlated with the use of software.

End user involvement was determined by measuring the degree of perceived risk, and the degree of pleasure incurred in using the software by Barki et al. (1993) with a questionnaire where users were asked to respond about their expected participation in information systems. Users answered yes or no rather than responding to a Likert scale because they had either participated in an activity or not. Barki et al. (1993) found support for the hypothesis that user involvement is positively correlated to motivational aspects in using software applications.

Success was measured in terms of satisfaction by Blili et al. (1998) because they felt that it was difficult to measure success with existing instruments. While Blili et al's study provides detailed information about the type of statistical tests performed, the study combined different questions belonging to the same construct in order to establish reliability. For instance, while measuring competence, usage frequency and usage duration have been combined. This is not desirable as frequency and usage represent two different units of measurement.

EUC training outcomes have also been evaluated using a questionnaire by Cronan & Douglas (1990). These consisted of questions on usefulness and user satisfaction as a measure of success of training. While most of the other studies did not perform tests of validity on questionnaires, Cronan & Douglas statistically tested questionnaires before results were analysed. Cronan & Douglas (1990) reported a positive correlation between usefulness and satisfaction.

Validity of subjective measures used in previous studies

Despite all these measures and procedures, it appears that subjective measurement of training outcomes lacks consistency in EUC studies. For instance, while certain studies have used yes/no type questions to measure usage, other studies have used a frequency scale. Therefore, it can be concluded that while EUC studies

[13] This appears to be a common practice in most of the studies. This study will also follow this approach. This is discussed in the Research Methodology chapter.

have subjectively measured training outcomes, some of the approaches taken to measure these outcomes have not been uniform.

Further, certain studies have statistically validated the data obtained from users and others have not. This lack of validation questions the reliability of the questionnaire items and the inter-relationships between questions in the survey or questionnaire. Therefore, there is a need to carefully consider the way in which these survey or questionnaire instruments are developed and validated.

In addition to this, some studies have asked a range of questions and have simply summed up user responses to arrive at an average. This average has then been used in statistical tests. The method of averaging different elements in a questionnaire or survey does not provide useful guidance in terms of what is being measured.

Training materials and tasks

Training materials typically reflect training approaches and instructions are provided in order to learn given software applications. Training materials in EUC have been organized in terms of tasks that need to be accomplished in order to understand application software packages. These tasks are in turn provided to users in the form of instructions. EUC studies have dealt with tasks in terms of task sequences and task complexity. Instructions are dealt with in terms of text elaborations, training approaches and design of instructions.

Training materials in EUC studies have focused on practical tasks such as the activities involved in using a word processor. These studies have recognised the need to involve users and hence the tasks are targeted at getting hands-on experience. For example, in the training materials developed by Carrol et al. (1987) learning objectives were broken down into a number of tasks and labeled for users to refer to them quickly. Each task included open-ended exercises to enable learners to plan and carry out certain activities to address the learning objectives.

Carol's study also recognised that users commit errors while learning and therefore included error recovery details to assist users. Carrol et al. (1987) found that commercial manuals (at that time) did not include error recovery. Training materials have since been constructed in such a way that potential errors are identified well in advance and instructions are given to users to avoid these errors, for example, when users are asked to check the availability of a file in a floppy diskette. Before such a check is conducted, users are reminded that the floppy diskette should be available in a specified drive. This has been done by properly coordinating system resources such as identifying the correct hardware drive for operations and then sequencing the tasks.

Task complexity is also dealt with in EUC training materials. Malhotra (1982) has studied the characteristics of task complexity and has identified it as an independent variable which is affected by time pressure, increases in data, information overload and user uncertainty. Payne (1976), Olshavsky (1979), and Corcoran (1986) support the hypothesis that task complexity increases demands on the user's information processing ability and affects training outcomes. Mayer (1981) has justified the importance of task complexity by distinguishing tasks into near-transfer tasks, which need just recalling information from short-term memory and far-transfer tasks, which need information accessed from both short-term memory and long-term memory, and he subsequently established their influence on information processing. There is support for the argument that task itself needs to be clearly defined and there is a need to take into account the processes by which users assimilate information via tasks (McGuire, 1985). Tanner (1987) states that a description of the nature of the task and an understanding of how its characteristics influence cognitive strategies should be included in any investigation of task complexity.

Wood (1986) developed a theoretical model of tasks and task complexity. This model describes three components of tasks: products (i.e. the measurable results of acts), acts (i.e. the pattern of goal-directed behaviours), and information cues (i.e. the stimuli that can be processed to make judgments). Task complexity, according to Wood, represents the relationship between task inputs and helps determine performance by the demands it places on the knowledge, skills, and resources of the decision-maker. Wood's model of task complexity includes three types of complexity: component, coordinative and dynamic complexity. Component complexity refers to the number of distinct acts that need to be carried out and the number of information cues presented. Coordinative complexity describes the form and strength of the relationships between task inputs and between inputs and task products. Dynamic complexity includes variations in these relationships such as sudden change, continuous change, and predictable or unpredictable change.

Campbell's (1988) model of task complexity relates directly to task attributes which increase the information load, diversity, or rate of change. Campbell describes task attributes as (i) multiple potential paths to desired outcomes, (ii) as multiple desired outcomes to be attained, (iii) as conflicting interdependence among paths to multiple outcomes, and (iv) as uncertain or probabilistic links among paths and outcomes. Campbell (1991) further organised these task attributes into three groups identified as "how-to-get-there" (path) tasks, "which to choose" (choice) tasks, and "prediction" (judgment) tasks. According to this typology, complexity is determined by the degree to which a task includes each attribute and by the total number of attributes contained in the task.

Both Wood's and Campbell's models are limited to the characteristics relevant to what Markus & Zajonc (1985) describe as the immediate processing act, that is, the cues or information taken into account while processing and which may be considered as the content of the information-processing task. In training, the effects of the surrounding milieu and prior knowledge play a significant role in the decision-making process.

While task complexity is characterised as the number of attributes or dimensions to be considered, other characteristics include number, uncertainty (or ambiguity), conflict and change. Task has been investigated in instructional theory in terms of five characteristics: number, irrelevance, ambiguity, conflict, and change (Dick & Carey, 1990; Edmonds et al., 1994). Number is the total amount of information (e.g., cues) in the content component of the task or the number of variables (e.g., family members) in the context of the task. Time pressure is a specialized example of number where a decreased amount of time is available to make decisions. Irrelevance is information in the content of the task that is not pertinent to the decision making, or that diverts attention away from the task at hand. Ambiguity is lack of clarity, obscurity, unreliable evidence, incomplete information, vagueness, or the possibility of assigning multiple interpretations or meanings to data. Conflict is the mutual interference of opposing forces or information. Change is difference, fluctuation, or variation in form, quality or state. According to Edmonds et al. (1994) task complexity plays a crucial role in training and training materials should contain tasks which users can easily understand. A task that is well designed would allow the smooth transition of acquired knowledge into daily practice.

Training materials in Olfman & Mandviwalla (1995) explore the relationships among components of skill learning in software training through three types of instruction sets[14]. The first set consists of rich procedure based instructions (referred as rich-P manuals). This set contain instructions to support procedure elaborations in terms of tasks but contain sparse conceptual and usage elaborations. The procedure elaborations describe the procedures needed to perform an operation in the software environment. For instance, the description of a MOVE command is limited to procedures explaining how to move a number from one cell in a spreadsheet to another cell. The second set consists of procedures and concepts and is referred to as rich P-C set. This set includes rich procedural and conceptual elaborations to highlight how tasks are conducted and the underlying concepts to facilitate understanding but sparse usage elaborations. In this manual, the MOVE command's concept in the environment is detailed along with the procedures. The third set of instructions include procedural, conceptual and usage instructions and called the P-C-U. This set of instructions consists of rich procedural, conceptual and usage elaborations to demonstrate how tasks are handled, the underlying concepts and their usage in a given environment. The MOVE command and its variations are elaborated in this instruction set. The inclusion of rich procedure based manuals stem from Reder et al. (1986) who established that these procedures increased the initial learning of command-based operating system software as compared with the sparse elaboration. While Reder et al. did not separate conceptual and usage concepts, Olfman & Mandviwalaa considered these in their study.

Davis & Bostrom (1993) reported on two types of training approaches – instruction and exploration. The instruction-oriented approach consists training instructions that are highly programmed and allows users little digression from the materials given to them. They must follow the sequences provided and are required to deduct information from previous sequences in order to understand instructions. Instruction material is feature focused, because the training is provided to understand particular features of the product.

Exploration training materials, on the other hand, consist of instructions that follow an inductive approach where users learn by trial and error methods by

[14] In this case it is Lotus 1-2-3 spreadsheet environment.

exploring the product. Hence, little control is placed on the users and they can freely explore the product in a way that is not possible with task-based training. These training materials are organised based on the notion that the sequence of learning is not important.

Further studies have examined the influences of two types of instructions featured in EUC training: process features and structural features (Black, 1995; Carrol & Rosson, 1995; Davis & Bostrom, 1993). Process features describe the mechanisms by which individuals carry out learning instructions and structural features refer to the organisation of training instructions.

Olfman & Mandviwalla's (1994) study examined the effectiveness of training materials in EUC training specifically looking at the environment in which training is offered and use of the system, based on the training instructions provided. In this study, concept-based training instructions and procedure-based training instructions were produced. The concept-based training emphasised software syntax and encompassed a set of instructions to describe and define the functions of objects, such as icons found in the application software. To introduce the concept-based training, the tasks were sequenced using a task hierarchy in order to move from basic tasks to complex tasks. Procedure-based training, on the other hand, focused on the connection of high-level tasks and actions encompassing a set of instructions and syntax. The procedure-based training provided instructions to construct complex tasks from simple tasks.

Wiebe et al. (1993) discussed training materials in terms of the sequence and order of instructions and the need for instructions to match tasks. Wiebe et al. highlight three major aspects in any training materials based on tasks, i.e. steps, key points and comments, and argues that these help users to avoid any potential errors. Wiebe et al's study emphasised the need to define the steps involved in accomplishing a task, the need to eliminate user interpretations, and the necessity to easily modify and update materials. In addition, the study explored the need for presenting readable training materials.

Craig & Beck (1993) highlight the need to define learning objectives before the production of training materials and Nelson et al. (1995) also support this concept. Studies from the instructional design, such as Dick & Carey (1990), argue strongly for this approach, as instructional designers should be able to specify what needs to be measured once the instructions have been given to subjects. Dick (1990) has provided a sequence of steps for designing instructions for short training programs which begins with definitions of learning objectives and concludes with formative and summative evaluations.

The studies reported in this section have considered aspects of training materials for instructions to be imparted for learning purposes. While some studies have just focused on how to present instructions to perform a task, others have concentrated on the type of training approaches. Some studies have also focused on the features of training instructions. While the training materials in EUC have predominantly focused on instructions to handle tasks in an application, studies in instructional design have investigated various aspects of tasks themselves. This investigation has included task characteristics such as complexity. Therefore, to prepare instructions for EUC training, in addition to what is reported in EUC studies, one should also consider instructional design elements.

Individual differences

While learning, individuals react differently. For instance, some individuals learn quickly and some others slowly. This is because of the influences of learning styles and associated cognitive styles on the process of learning. While learning consists of other factors, it is believed that these factors – learning styles and cognitive styles – influence the way in which individuals' process given information in order to understand and hence learn. This is discussed below.

Learning styles

Honey & Mumford (1992, p. 1) defines learning as follows:

In our view one has learned something when either or both of the following descriptions apply:

i. He knows something he did not know earlier, and can show it.
ii. He is able to do something he was not able to do before.

The term learning is traditionally viewed as being mediated both socially and cognitively and in classroom settings (Sadler-Smith, 1996) where pedagogical practices and learners' characteristics meet. The interaction between students and teachers also influences learning outcomes.

Typically learning involves five major components: learning preference (Dunn & Dunn, 1989), learning strategy (Ernest, 1995), learning style (Keefe & Monk, 1986), cognitive strategy (Riding & Cheema, 1991) and cognitive style (Curry, 1991). *Learning preferences* are individuals' preferred modes of learning and include the type of teaching, surroundings, materials and the delivery modes. *Learning strategies* refer to the actions which enable an individual to acquire the knowledge or skills through traditional education or training module. The distinctive and habitual manner with which one acquires knowledge is referred to as *Learning style*. It involves individuals' attitudes to the learning process which are developed through a combination of acquired knowledge and experience. This component deals with preferred styles of learning such as collaborative learning, type of interaction and other styles of communication. In addition, the way in which information is organised and processed results from *Cognitive strategy*. This cognitive strategy refers to the way the human brain perceives information in various forms, allocates it to various components in the brain such as short-term and long-term memory modules, and executes tasks using this information when stored on memory modules. *Cognitive style* refers to influences which affect cognitive processing such as focus of attention, approaches to problems, development of conceptual relationships, and information processing.

The above five components differ in terms of the degree to which each may be observed and described. While learning preferences are readily observed, other constructs such as cognitive style may need some form of psychometric test for observation (Sadler-Smith, 1996). A fundamental feature is "individual difference" which consists of unique learning styles and cognitive styles and which have been identified as two important aspects for the accurate measurement of learning outcomes.

During the process of learning, individuals construct meaning from what is presented to them in a variety of ways. Some people prefer to learn by active experimentation, others prefer to learn by interpreting theoretical concepts and yet others learn by inductive reasoning. However it is generally accepted that a learner uses all these styles in the process of learning (Ernest, 1995; Philips, 1995; Prawat, 1992).

Entwistle's (1979) work on learning styles is centred on levels of learning reflected either as surface or deep engagement with a task. These concepts are also discussed by Ausubel & Robinson (1968)[15] who identified two main types of contrasts in learning: rote-meaningful-learning and passive-active- learning. The rote learning is surface learning because learners just recall information from memory without understanding why such information is used. On the other hand, meaningful learning is deep because learners can connect information from various parts of memory to create a meaningful context. Similarly, in passive learning, learners process given information without really engaging in a task. In active learning, learners engage themselves in the task and understand the context.

Entwhistle linked instructional preferences to information processing and developed a model of learning styles which consisted of four aspects: meaning orientation, reproducing orientation, achieving orientation and holistic orientation. He also developed an integrated concept of the learning process which links learner actions to specific learning strategies. For example, a learner who is engaged in reproductive learning will adopt a surface approach and will achieve a learning outcome with surface level understanding. Entwhistle's model was further refined to incorporate learner orientation and specific styles of learning into the learning interface. Biggs (1985) extended Entwhistle's work to develop a new measure of learning incorporating the motivational elements underlying learning. Curry (1987) subsequently described Bigg's work as incorporating motive-strategy dimensions involving surface, deep and achieving orientations.

Schmeck et al. (1977) proposed a theory of learning based upon the notion of quality in thinking. Schmeck et al. argued that quality of thinking affects the distinctiveness, transferability and durability of memories that result from the learning event. This work was further developed to produce a style construct, which consisted of four subscales comprising synthesis-analysis, elaborative processing, fact retention and study methods.

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[15] The work of Ausubel & Robinson is discussed in a later chapter

Curry (1991) and Grigerenko & Sternberg (1995) have both commented on the close similarity between this model and the work of Entwistle (1979) in terms of style constructs. For instance, it can be seen that the synthesis-analysis dimension is similar to meaning orientation in Entwhistle's work. Similarly, fact retention is similar to the reproducing orientation in Entwhistle' work.

Reinert (1976) study aimed at identifying an individual's natural perceptual modality in learning. The study consisted of 50 one-word items which were used to characterise a respondent's reaction on four possible levels: (i) visualization or creation of a mental picture, (ii) alphabetical letters in written form, (iii) sound, and (iv) activity as an emotional or physical feeling about the word. The purpose of this experiment was to provide teachers with information to ascertain a student's strengths or preferred learning stimuli.

Gregorc (1982) argued that an individual learns through concrete experience and abstraction either randomly or sequentially. Gregorc's Style Delineator is a self-reporting measure made up of 40 words which the respondent is asked to rank to describe their self-perception as a thinker and learner. The measure indicates the position an individual occupies in the bi-dimensional channels of learning preferences for making sense of the world through the perception and ordering of incoming information. The Style Delineator identified four types of learners: (i) concrete sequential learners who prefer direct, step-by-step, orderly and sensory based learning; (ii) concrete random learners who rely upon trial and error, intuitive and independent approaches to learning; (iii) abstract sequential learners who adopt an analytic, logical approach to learning and prefer verbal instruction; and (iv) abstract random learners who approach learning holistically, visually and prefer to learn information in an unstructured experiential way.

The learning style construct defined by Keefe & Monk (1986) described 24 key elements related to learning styles which are grouped together into three areas: first, cognitive skills, which embrace information processing activity; second, perceptual responses which encompass perceptual responses to data; and third, study and instructional preferences which refer to motivational and environmental elements of style. The construct and the rationale for the construct's operationalisation were based upon the premise that cognitive skill development is a prerequisite for effective learning. In this respect, the approach was very much concerned with cognitive skills with a definite 'learning to learn' dimension. Keefe argued that if an individual cannot process information effectively, ineffective learning would take place, thereby minimising the effect of a positive learning environment.

Kolb's (1976) learning style inventory (LSI) is the most widely used instrument for identifying learning style preferences in the area of education (Bohlen & Ferrat, 1997). In LSI, learning embodies a four-stage cycle involving four adaptive learning modes – concrete experience, reflective observation, abstract conceptualisation and active experimentation. A learner is provided with some concrete experience, which is followed by some reflective observation on that experience. Then the learner forms some abstract concepts (or theories) which are tested through active experimentation. Kolb states that concrete experience and abstract conceptualisation form the opposite ends of a continuum of learning and that active experimentation and reflective observation form another continuum. Kolb asserts that learners will have a "preference" for learning on each of the two continua or axes. Kolb's LSI is designed to "measure" a learner's preference for learning on each of these two continua and the learner is then placed into one of the quadrants. Each quadrant reflects a particular learning style: convergent, divergent, assimilation and accommodative.

Those with *convergent* learning styles, convergers, include those learners that prefer abstract conceptualisation and active experimentation. The strengths of these learners are in problem solving, decision-making and the practical application of ideas. They prefer dealing with technical tasks and problems rather than social and interpersonal issues. Those with *divergent* learning styles, divergers, reflect those learners who have strengths opposite to the convergers. They prefer concrete experience and reflective observation. The greatest strength of these learners is their imaginative ability and their awareness of meaning and values. These learners tend to perform better in situations that call for the generation of alternative ideas such as "brainstorming". Those with *assimilation* learning styles, assimilators, prefer abstract conceptualisation and reflective observation. Their strengths lie in inductive reasoning and the ability to create theoretical models. They are more concerned with ideas and abstract concepts. It is more important for them that the theory be logically sound and precise, than for it to have practical application. Those with *accommodative* learning styles, accommodators, have the opposite strengths to assimilators. They respond to concrete experience and active experimentation. Their strengths lie in doing things, in carrying out plans and tasks and getting involved in new experiences. Accommodators tend to solve problems in an intuitive trial-and-error manner, relying heavily on other people for information rather than on their own analytical ability.

Honey & Mumford (1986) modified Kolb's approach into a learning cycle. In this model, the learners are classified according to their strengths and weaknesses rather than their preferences. The model suggests four contrasting stages of a learning cycle. They are activist, reflector, theorist and pragmatist. The model portrays activists as people who involve themselves in new experiences, tackling problems by brainstorming and moving from one task to the next as the excitement fades. The activists would respond unfavourably to a tutorial coaching situation; they would dislike the passive element. The activists welcome any novel experience. The learning response of activists would be unlikely to be effective in ordinary situations.

The reflectors are cautious and thoughtful. They would like to consider all possibilities before making any decisions. Their actions are based on observations and reflections. Reflectors produce carefully considered analyses. They welcome questions in response to their actions, but like to have sufficient notice to get organised. Reflectors may not require a lot of help beforehand.

Theorists are people who integrate their observations into logical models based on analysis and objectivity. They appreciate the theory behind action learning. Theorists might feel that conditions are ambiguous, uncertain and difficult to work with. They respond well to coaching that respects their intellect. In novel situations, they perform well, even if unprepared.

The pragmatists are practical people. These people like to apply new ideas immediately. They get impatient with any over emphasis on reflection. They would happily participate in exchanging ideas with others and usually build on and improve on what is being offered. Pragmatists would welcome opportunities and make effective use of them. They would be unhappy if they were not consulted when ideas are conceived.

In summary, while many studies have provided useful information on learning styles, of particular note for EUC training was the learning style analysis by Keefe

(1986) that included three components – references to information processing, references to data and references to instructional preferences. These three elements play significant roles in determining the influence of application interfaces on training. Therefore, it is possible to hypothesise that different users will have varying preferences in learning, and that this variation will have a bearing on training outcomes. Hence it is possible to provide new knowledge that is not currently available in EUC.

It can be seen from the above studies that experience and theory have been considered as two distinct dimensions. While Kolb's LSI is mentioned as the dominant instrument, the applicability of this instrument is questioned by Ruble & Stout (1993) with regard to EUC training in Bostrom et al.'s (1990) study in particular. In response, Bostrom et al. have replied that while the statistical validity is questionable, there is no doubt about the face validity (or what is generally known as content validity) of Kolb's instrument when applied to short training programs. Honey and Mumfords's Learning Cycle, on the other hand, is widely used in Europe for the design of short training programs and overcomes the problem of statistical validity.

Cognitive styles

Miller (1991) and Riding (1994) define the term cognitive style as a person's typical or habitual mode of problem solving, thinking, perceiving and remembering. In general, a cognitive style is perceived as the way in which information is interpreted. Vernon (1963) provided an early critique of cognitive style, tracing its development from work carried out by German Gestalt psychologists. Vernon explained that subsequent work on style flowed from a considerable number of experiments devoted to studying individual differences in perception.

Riding (1991) proposed two dimensions of cognitive style: the Wholist-Analytic and the Verbaliser-Imager. First, with a wholistic-analytic style, people process information and either take the whole view or see things in parts. With the verbaliser-imager style, people represent information or thinking either in pictures or in words.

Witkin & Goodenough (1988) focused their study initially on perception, as individuals identified differences when locating an upright object in space. Witkin &

Goodenough's work reflected earlier research into perception carried over by the Gestalt school of German psychology. Further experiments by Witkin & Goodenough led to the discovery of field-independent and field-dependent perceptual styles through the discrimination of shapes (Witkin & Goodenough, 1988), and involved a range of functions relating to psychological differentiation reported by Kagan et al. (1964). Field independent children were found to have a greater capacity than field dependent children for "active analysis" and perceptual "differentiation". They were more likely to prefer independent activity, to have self-defined goals, to respond to intrinsic reinforcement and to prefer to structure or restructure their own learning. They were also more likely to develop their own learning strategies. Field-dependent children, on the other hand, were found to have a preference for learning in groups. They interacted more frequently with peers or with the teacher, needed higher levels of extrinsic reinforcement and direction, stated performance goals or established structure in an activity. Riding (1991) reports that later cognitive studies have focused on field dependency and learning, as these studies were based on "tasks".

The Impulsivity-Reflectivity dimension was originally introduced by Kagan et al. (1964) and is measured by the "Matching Familiar Figures Test" (MFFT). This cognitive dimension was derived from earlier work investigating conceptual tempo, or the rate at which an individual makes decisions under conditions of uncertainty. Learners were divided into two groups. The first were those who reached a decision quickly after a brief review of options and were labelled "cognitively impulsive". The second were those who would deliberate before making a response, carefully considering all options, and were labeled "cognitively reflective". Riding (1991, 1994) notes that this aspect of cognitive functioning relates to tasks involved in both academic and non-academic learning.

Guildford (1967) proposed the Convergent-Divergent dimension of cognitive style to explain the thinking and associated strategies required for problem solving. A learner will follow either an open-ended exploratory or a closed-end focused approach to problem solving. The problem is usually divided into small tasks. Hudson (1968) further developed this theory and its implications for the process of teaching and learning.

Pask (1976) introduced a Holist-Serialist label to describe two competencies which reflected an individual's tendency to respond to a learning task either with a holist strategy, which is "hypothesis-led" or with a focused strategy which is characterised by a step-by-step process and is "data-led". This work by Pask led to the development of "conversational theory" which emphasised the facility of the learner to "teach-back" learned material (Clapp, 1993; Taylor, 1994; Van Der Molen, 1994).

Kirton (1976) argued that cognitive style relates to the preferred cognitive strategies involved in personal response to change, creativity, problem solving and decision-making. A second key assumption made by Kirton was that these strategies are related to aspects of one's personality that appear early in life and which are particularly stable, such as cognitive style. The dimension developed by Kirton is called Adaption-Innovation (A-I Theory), and is understood to exist early in an individual's cognitive development and to be stable over both time and incident. The adaptor, represents a preference for doing things better, while the innovator represents a tendency for doing things differently. Kirton developed an assessment instrument to measure his adaptor-innovator continuum. This is called the Kirton Adaptor-Innovator Inventory (KAI). It is a self-reporting inventory originally designed for adults with work place and life experience. Kirton also provided evidence to support the reliability and validity of the instrument which is also corroborated by others such as Jonassen & Grabowski (1993). The KAI produces a score which, Kirton claims, represents an individual's preferred cognitive style either as an adaptor or an innovator.

Kaufmann's (1989) work stemmed from an interest in problem solving and creativity. He identified two groups of problem-solvers: assimilators and explorers, and extrapolated an A-E theory of cognitive style to apply to problem-solving behaviour. Kaufmann's Assimilator-Explorer (A-E) Inventory, contains a 32-item forced choice self-reporting questionnaire, in which items describe dispositions towards cognitive "novelty-seeking against familiarity-seeking". Explorers reflected a higher score on the bi-polar continuum. The A-E instrument was organised to reflect three factors: novelty against structure seeking, high against low ideational productivity and opposition against preference for structure. Martinsen (1994) has continued work in this area, specifically on the relationship between cognitive style, insight and motivation in the process of problem solving.

The cognitive style index (CSI) developed by Allinson & Hayes (1996) is aimed at the "... generic intuition-analysis dimension of cognitive style". Allinson & Hayes have argued that this instrument is essential for the operationalisation of cognitive style in a professional context. CSI has been designed to research cognitive style in management practices. It focuses on a dimension which reflects the duality of human consciousness, that is, either intuitive or analytic. The CSI is a self-reporting questionnaire. It is relatively short and produces a score that reflects an individual's position on an analytic-intuitive continuum, which the authors argue, reflects the super-ordinate dimension of cognitive style. The construction of the questionnaire is described in some detail by Allinson & Hayes (1996), in an attempt to identify a unitary construct of cognitive style and to operationalise that same construct in the professional context of business management.

It can be seen from the literature, therefore that the study of cognitive styles involves investigating an individual's habitual problem solving processes. One aspect which emerges from this literature is the lack of consideration given to cognitive styles in EUC studies. While some EUC studies have considered the impact of different cognitive styles, they have often been criticised for the choice of instruments to measure this impact (Ruble & Stout, 1993) and which have prompted conflicting explanations in training outcomes. Bostrom et al. (1990) have suggested considering varying cognitive styles in EUC training in order to explain varying training outcomes. Mayer (1981) support this concept by explaining the nature of information processing and its relevance to tasks in training materials.

Another relevant aspect in EUC is how users see information. In computing, users are introduced to information by the way of interfaces represented as icons or text strings and different cognitive styles will respond to images or text differently. Further, different cognitive styles will see information either as a whole or as a set of component parts. These "views" can influence information processing. So, when a training framework is postulated, these aspects need to be considered very carefully. This can only be done once individual learning preferences and cognitive styles have been established.

General Discussion on Interface Design

In modern desktop environments, users communicate with applications by accessing elements such as menus, short-cut keys, dialogue boxes, forms and icons. These access mechanisms, often called interfaces, play a crucial role in the way in which users complete a given task (Tang, 2001).

Among studies on interfaces are there that concern the design of interfaces, which includes, for example, the principles behind designing interfaces. Their main purpose is to establish how the human brain understands the shapes and symbols used to represent these interfaces and how this understanding is transformed and facilitated during information processing. Details of these studies are mainly found in the area of Human Computer Interaction (HCI). Interface design is broadly covered in this thesis to provide an understanding of the development of 'interfaces' that are used by end users. In the EUC domain, the focus has been on the usage of these interfaces to highlight how one particular type of interface is superior to another in a given setting. This aspect is the main focus of this thesis with the setting being end user training.

The Nature of Interface Design

Interfaces are designed and developed for the purpose of interaction (Shih & Goonetilleke, 1998). Interfaces, when designed effectively, generate positive feelings of success, competence and clarity in the user and also create an environment in which tasks are carried out almost effortlessly (Tang, 2001). There appears to be three major stages of development in the area of interface design. The first stage focussed on design principles and studies prior to 1990 appear to have concentrated on issues associated with design principles. The second stage of interface design, between 1990 and 1998, appears to have focussed on multimedia capabilities. The current development appears to be involving intelligent agents and how interfaces can be bundled with intelligent software modules in order to perform user tasks. This development appears to focus on web-based applications. With this scope in mind, interface design is discussed in the following sections.

Interface design principles and considerations

There are five main interface design considerations in the development of interfaces (Gentner & Nielson, 1996; Shneiderman, 1982). These are consistency, provision for feedback, minimising error possibilities, providing error recovery and accommodating multiple skills.

A *consistent* interface is one in which the conceptual model, functionality, sequencing and hardware bindings are uniform and follow simple rules (Gentner & Nielson, 1996). Consistency allows users to employ generalised knowledge about one aspect of the interface when using other aspects. *Feedback* is essential to establish proper dialogue with users. Each user action needs to be matched with appropriate feedback (Neesham, 1990). In addition to this, when the interfaces enable interaction with certain hardware devices, feedback should be given to indicate the status of the hardware devices and the status of tasks being processed. Feedback can be grouped into two categories: problem domain feedback and control domain feedback. Problem domain feedback concerns the actual objects being manipulated such as the object's appearance, position and existence. Control domain feedback concerns the mechanisms for controlling the interfaces such as status, current and default values.

Errors need to be minimised to realise other goals of interface design and to avoid any side effects such as users committing further mistakes or applications behaving unexpectedly (Shih & Goonetilleke, 1998). Side effects are results that the user has not been led to expect and generally arise from poor interface design (Shih & Alessi, 1994). *Error recovery* allows users to freely explore unlearned system facilities without fear of failure (Shneiderman, 1982). Essentially this freedom is provided to encourage exploratory learning. Recovery should also be provided for errors committed by users while accessing operating system functions.

Multiple skill levels need to be accommodated when designing interface styles in order to accommodate various user levels (Lewis, 1998). New users feel comfortable with menus, forms, and other dialogue styles that provide considerable prompting. These prompts tell them what to do and facilitate learning. More experienced users, however, place more value on speed of use. This requires function keys and keyboard short cuts, which are also called accelerators.

Schiff (1980) argues that interface design should consider users' fear of making mistakes which leads to embarrassment or feelings of incapability. By providing well-designed interfaces, mistakes can be prevented or at least minimised.

According to Schiff (1980), this is an important interface design consideration. Preece et al. (1994) suggested that interfaces are capable of providing rich instruction to users while interacting with input and output devices of a computer. Hence, they are of the opinion that the term human computer dialogue should be extended to incorporate the richness of potential instruction giving activity and hence the term 'human computer interaction' to include a wide range of and interface components of different styles. Preece et al. (1994) discuss command entry interfaces, menus, question and answer formats, form filling interfaces and natural language dialogues[16].

Benyon et al. (1999) state that users should be accounted for in interface design because user's conceptual model can be reinforced by using different interface techniques. For example, Norman (1993) provides a discussion of one such technique called metaphors, which is based on an analogy, and is constructed based on previous knowledge, allowing users to transfer this knowledge to the interfaces. In another interface designing technique, called 'user driven interface', the task is analysed and then interfaces are built which mimic manual processes, such as the transferral of paper-based processes to computer applications.

In EUC training, Bostrom et al. (1990) argue that successful interface design should accommodate individual user differences. In other words, human diversity needs to be considered. To include these differences, interface designers should understand the varied cognitive and perceptual abilities of users. The cognitive aspects of information processing include short-term memory, long-term memory and time perception. Riding (1997) argues that the ability to search and scan these cognitive aspects is essential to be successful in understanding and interpreting given information. Ramsden (1979) highlights the necessity to understand and incorporate personality differences[17] while discussing cognitive aspects. Personality is often correlated with learning style. Hence, learning styles and learning preferences must also be considered when interfaces are designed (Witkin & Goodenough, 1988).

Jonassen & Grabowski (1993) assert that users move from the beginning stage to an expert stage. They investigated to find out how smooth this transition is.

[16] These interface types are discussed later.

[17] Unfortunately, there is no simple instrument available to measure user personality accurately (Riding, 1997) and has therefore not been considered in this study.

They recommend that interfaces be designed in order to accommodate different levels of expertise. There is support for this argument from other studies (Carnevale & Carnevale, 1994; Chaney & Wills, 1995; Mayer, 1981).

Dix et al. (1998) state that when designing user interfaces, it is important to first decide the appropriate style to suit user task and characteristics. Johnson & Nemetz (1998), while discussing principles for the design and evaluation of multimedia systems state that the while there is significant growth in multimedia systems, the interface design principles to address this growth hasn't developed yet. While discussing multimedia interface design principles, they state that the design principles should address naturalness, media allocation, redundancy, exploration and quality of information representation.

Key design goals

Shih & Goonetilleke (1998), Shneiderman (1982) and Lewis (1998) state that the key goals in interface design are increase in speed of learning, increase in speed of use, reduction in error rate, encouragement of rapid recall of interface features, and an increase in attractiveness to users. These five goals are measured using the time taken to learn interfaces, speed of performance of using interfaces, rate of errors committed by users while using interfaces, subjective satisfaction and retention of meaning of interfaces over time (Laurel, 1990). In EUC studies, Davis (1985), Bostrom et al. (1990) and Sein et al. (1993) mention that measurable objectives need to be established at the training design stage because of the role played by individual differences[18] in determining the role of interfaces in EUC training.

[19]The speed of learning concerns how long a new user takes to achieve a given level of proficiency with a system. The speed is associated with time and sometimes denoted as time to learn. The *time to learn* is affected if the interface is complex and more time is taken to learn the interface and hence to complete a task. *Subjective satisfaction* is the level of satisfaction with a particular interface and it appears that when errors are minimised, users are satisfied with the system. Usually, this is ascertained by interviews or written surveys that include satisfaction scales and space

[18] While human factors encompass activities such as how information is presented, shape, size, position etc, individual differences specifically define the cognitive aspects of human activities.

[19] The following paragraphs provide addition information on the five goals mentioned in the previous paragraphs in the author's own terms.

for comments. *Retention over time* refers to how well users maintain their knowledge after a specified time block, for instance one hour, one day or one month. Retention is closely linked to time to learn, frequency of use and the cognitive aspects of information processing including retrieval.

Speed of use concerns how long an experienced user takes to perform some specific task within a system. Usually usage is measured and denoted in terms of performance. Therefore, *speed of performance* deals with the time taken to complete a task compared to an ideal condition that has already been benchmarked. During tasks, interfaces interact with other system resources, therefore, internal communication aspects are also studied while measuring this aspect. This is critical when a person is to use the system repeatedly for a significant amount of time.

The error rate measures the number of user errors per interaction. *Rate of errors* refers to how many and what kind of errors are made in carrying out the benchmark set of tasks. Although time to make and correct errors might be incorporated into the speed of performance, error making is a critical component of system usage. Interface designers consider that the communication aspects of interfaces are not clear when errors are made. Further, this leads to frustration and, as a result, motivation to use an interface decreases. This affects both the speed of learning and the speed of use. If it is easy to make mistakes with the system, then learning takes longer and speed of use is reduced because the user must correct any mistakes. Rapid recall concerns how quickly users remember the interface functions when returning from an absence from using the system. Attractiveness of the interface concerns aesthetic aspects such as how the interface is presented to users.

From the above, it can be inferred that the key interface design goals are developed for 'interface usage'. Prior to a discussion on interface usage in EUC studies, a discussion is necessary to highlight the types of interfaces used by end users. This is provided below.

Interface Types

Varying interfaces design have led to the identification of types of interfaces. They include metaphors, direct manipulation, see-and-point, What You See Is What You Get or WYSIWYG (Gentner & Nielson, 1996); menu interfaces (Shih & Goonetilleke, 1998); graphical user interfaces or generally referred to as GUI (Lewis, 1998); Windows, Icons, Menus and Prompts (WIMP), natural language dialogue (Nielsen, 1990). These types of interfaces are referred as graphical user interfaces (Neesham, 1990). Recent development in interface types includes 'intelligent interfaces'.

Non-graphical user interfaces are usually command-strings entered using editors. These are also termed command-type. These interfaces were in use prior to the introduction of Windows Operating Systems (Carrol et al., 1987). While the traditional interface style in earlier systems is based on command language, there are problems associated with this type (Davis & Bostrom, 1993). For instance, learning time is a major liability and errors are more likely due to incorrect typing or recalling. However, command languages can accommodate large selection sets, and are easy to extend. They are fast for experienced users and for users who can type.

Metaphors are used to convey verbal instructions using an analogy (Gentner & Nielson, 1996). One of the popular examples of the metaphors is the Macintosh' representation of trash can on desktop to denote any unwanted computer documents can be dropped on to this trash can in order to be trashed. It may not be possible to provide analogy to all user situations and this is considered to be a weakness of the metaphor interface type (Gentner & Nielson, 1996).

A direct manipulation interface is one in which the objects, attributes or relations are represented visually. Operations are invoked by actions performed on the visual representations, typically by using a mouse. That is, commands are not invoked explicitly by such traditional means as menu selection or keyboarding but are implicit in the action on the visual representation. This representation may be a text string, name of an object, or an icon. Direct manipulation is sometimes presented as being the best user interface style (Shneiderman, 1982). It is quite powerful and easy to learn.

The see-and-point interface type facilitates users to interact with the computer by pointing at the objects they can see on the screen (Gentner & Nielson, 1996). The interface types use hard devices such as mouse to fulfil user actions. User commands are accomplished by using mouse buttons by facilitating an expressive language. The real expressive power of the interface language comes into effect by the formation of structure of the 'pointing' conditions. For example, in Microsoft Word applications, the 'pointer' changes direction or shape indicating the functions that can be accomplished.

WYSIWYG is fundamental to interactive graphics (Shneiderman, 1982). The representation with which the user interacts in a WYSIWYG interface is essentially the same as the image ultimately created by the applications. Most current applications consist of WYSIWYG interface features (Nielsen, 1990). One of the main advantages of WYSIWYG interfaces is that there is no need for the users to translate their mental images into the application's functions. For example, in a non-WYSIWYG system, users have to write certain control codes to translate their mental images, for example, when making a selected text bold. The influence of the control code is not visible until the code is processed. WYSIWYG interfaces, on the other hand, show the influence of an action as soon as it is performed.

Menu interfaces provide the option of grouping command sets in a hierarchical order either vertically or horizontally. Menus provide text-strings and hence facilitate easier understanding of commands. Due this reason, menus are considered to reduce the load placed on memory in recalling the meaning of the interface type. This interface type discussed in detail later.

Windows, Icons, Menus and Prompts (WIMP) interface styles facilitate interface design by combining different types of interface techniques. Advantages of this type include reduced memory load and increased ease of use (Nielsen, 1990).

Natural language interface style is often proposed as the ultimate objective for interaction (Nielsen, 1990). The rationale behind such an argument is that if computers can understand our commands, typed or spoken in everyday language, then everyone will be able to use them. It is time consuming to train computer systems to understand one's voice. In addition, it is very difficult to package a command in a natural language that a computer system can understand as the command can be expressed in many forms. These may lead to poor performance by computers and frustration at the users' end.

One example of a natural language interface is the Question Answer dialogue interface style. But, invariably the user responses are constrained by a set of expected answers. In many cases, a dialogue box may provide the range of expected answers and this can reduce errors. One major problem with this interface style is that it is difficult for the users to go back and correct errors as this involves sequential backtracking.

Another form of interface, called the 'intelligent interface', is defined by Eberts (1994) as the interfaces that utilise knowledge bases. Eberts provides an early example of this interface used by referring to the MYCIN program of Shortliffe (1984), which enabled users to question an expert system as to how a specific diagnosis was made. Hefley & Murray's (1993) suggestion that the agent-based interaction can be used to delegate specific tasks for the user can be interpreted as a reference to the development of intelligent interface. The comment made by Maes (1994) that the agent is not necessarily an interface between the computer and the user is noteworthy because the agent assist users by hiding complexity of a task performed by the user. It is the agent software that monitors events and procedures rather than the user. Traditional interfaces, while accomplishing user tasks, do not address these complexities.

Icons versus Menus

Icons and menus are generally available in end user applications and hence are the focus of this study. The distinction between other interfaces, such as dialogue boxes, and menus and icons, is that the former extracts user preferences before accomplishing tasks whereas menus and icons usually accomplish tasks on the click of the mouse button. Further, menus and icons also represent a command set in the form of visual representations. In end user applications, both icons and menus represent certain actions, for example such as 'save', and hence it is possible to establish the impact of these interfaces on training outcomes.

An icon is a pictorial representation of an object, an action, a property or some other concept (Gentner & Nielson, 1996). Interface designers often have the choice of using icons or words to represent such concepts. Icons satisfy three major goals: recognition, remembering and discrimination (Dix et al., 1998). Icons that represent objects can be designed easily but icons can also represent actions. One icon design strategy is to include the status of an object before and after execution (Dix et al., 1998). Arbitrary icons are difficult to recognise. Further, it has been proven that icons may either be poorly used or not used at all (Goonetilleke et al., 2001).

Icons come under the category of direct manipulation interfaces. Due to the pictorial representation of icons, the term direct manipulation graphical interfaces (DMGI) is also found to represent icons (Furnas, 1991). Bevan (2001) reports that studies also have grouped icon interfaces into object icons, pointer icons, control icons, tool icons and action icons. Bevan (2001) refers to the ISO/IEC 11581 standard specification for these icons and provides a list of various shapes and representations of these icons. For instance, Bevan states that there are about 20 icons in the ISO/IEC 11581 standards specification for object icons and refers to their functional aspects. In addition to these commonly used interfaces, Bevan also mentions that the ISO standard specifies multimedia control and navigation icons, media selection and combination icons and domain specific multimedia interfaces

Icons provide visibility of the object of interest, rapid, reversible, incremental actions, and replace complex actions by simple object of interest (Eberts, 1994). Well-designed icons can provide enthusiasm and elicit enjoyment from their users. According to Shneiderman (1982) this is due to the factors such as ease of learning by novices, rapid usage by experienced users, retention of operational concepts by users, provisions to immediately notify users of their action and confidence and mastery gained by users because the action initiated provides immediate response in addition to predicted system response. However, one major problem with icons is that not all tasks can be described by concrete objects and not all actions can be performed directly (Eberts, 1994).

Menus are used widely in both graphic and non-graphic applications. Tang (2001) provides a thorough analysis of menu interfaces and lists the following characteristics:

- Menu interfaces usually provide a list of options of commands in a hierarchical manner and these commands can be accessed either by pointing (and then clicking) the mouse pointer or by using the associated short-cut key (if available).
- Menus can be pull-down, pop-up or cascading. These operational styles provide menus the visual momentum.
- Menus reduce the burden placed on the user memory because text strings are not cryptic and based on English like languages. As the text-strings readily provide

the meaning of the command, menus reduce memory load in recalling the meaning of the text-strings.

- Menus are also categorised in terms of items of importance to facilitate easy navigation by users. This categorisation helps users to quickly navigate certain components of the menu structure and identify the command set that they need.
- Menus provide wider usage options than command entry by providing text-strings that can be pointed and clicked using a mouse and by providing short-cut keys.

The fundamental advantage of menus is that the user can work with what is called recognition memory, where visual images are associated with already familiar words and meanings (Shih & Goonetilleke, 1998). This is different from recall memory where the user must recall a command or concept in order to enter information (Mayer, 1981). Menus reduce the memory load for users, and hence are especially attractive to novices as they allow current selections to be indicated visually (Shih & Alessi, 1994). However, menus must be limited as to the number of alternatives for selection because of screen size (Gentner & Nielson, 1996).

In summary, the design of interfaces deals with the principles underlying interaction with applications. It addresses issues of speed and accuracy aiming at greater speed and fewer errors during such interactions. In addition to these, studies have provided measurable objectives in order to establish superior interface design. Interface design also plays a crucial role in the formation of conceptual models of applications.

Interface Usage in EUC Studies

The usage of interfaces in EUC training is determined by the characteristics of this environment. This includes giving considerations to the users, the system they are likely to be using, the ease with which they are able to learn new application software, and so on. To take the above into account it appears that two major types of interfaces are popular in the ECU domain. They are command-based and direct manipulation (Davis & Bostrom, 1993).

Command-based interfaces use a conversational metaphor to facilitate users to enter and read English-like commands (Davis & Bostrom, 1993). DOS-based systems and Unix-based systems are examples of command-based interfaces. The computer system understands a command by matching it with a list of available commands. When an error is committed, the computer interacts with the user by stating the nature of the error. The user must then rectify the error and re-enter the command. Once the right command is provided, the system will execute the command. Commands can either be unary such as "stop", or binary such as "find file" or provided with a set of parameters such as "find file a*.com", where "a*.com" is a parameter instructing the computer to find all files starting with the character "a" and with extension "com" file extension.

Direct manipulation interfaces (DMI) allow users to point and click on symbols. The graphic symbols such as GUI represent a specific type of command that is activated under certain predefined conditions. For example, to save an active file the user may click on a symbol in the form of a floppy disk on the toolbar. The symbol indicates that the active file will be stored in a specified location. The click action would then be interpreted by the computer as having to perform a set of actions based on the given conditions.

Another form of DMI, the menu based interface, requires users to select a command from a set of text string options packaged into a list. The list is usually presented in the form of a pull-down menu, where the selection is activated either by the mouse or by pressing a short-cut key. This action then opens further menu options through which users can navigate. The mouse provides random selection of menu choices while the keyboard arrows navigation through menu items one by one. Therefore, these interface types present a model of the computer system (Davis & Bostrom, 1993).

According to Davis & Bostrom (1993), EUC studies have compared the DMI with command-based interfaces in order to establish the superiority of these interfaces in terms of their ease of learning, performance or impact on user perception of computer systems. Davis cites Chin (1984), Fryer (1991) and Walkenbach (1992) and states that direct manipulation interfaces (DMI) are more effective in terms of learning outcomes. He also cites Carrol & Mazur (1986) and Dumais & Jones (1985) to state that interface show no benefit in learning. It should be noted that the studies (cited by Davis) have been criticised for their lack of theory (Hutchins et al., 1986) and as a result, their findings tend to be unclear and contradictory. While these studies provide useful information regarding the relative effects of DMI versus command-based interfaces, they offer little justification for their results.

Sein et al. (1999) argues that interfaces play a crucial role in determining performance outcomes. This argument arises perhaps from Shneiderman's (1982) view that the knowledge content of a software application consists of the syntax and semantics of the commands used in its application. According to Sein et al. (1999) without knowledge of the commands available in an application, users cannot recover from errors or transfer their knowledge from one system to another. Thus EUC training frequently focuses on command-based knowledge.

Bostrom et al. (1990) study treated interfaces in terms of *mapping via usage.* He asserts that a novice forms a mental model of the system in three different ways – mapping via usage, mapping via analogy and mapping via training. Following the mapping via usage path, application interfaces play a crucial role in developing an accurate mental model by providing the internal representation of the system.

This approach is supported by other studies (Davis & Bostrom, 1993; Olfman & Mandviwalla, 1994; Sein et al., 1993) which argue that the interfaces are representative of the system itself. It appears that interfaces can provide a model of a computer system by presenting a manipulable equivalent of the conceptual model, as in icon-based direct manipulation systems, or by presenting an implicit model through the functions provided by a command based language or menu system.

Sein et al. (1993) provide details of a link between visualisation ability and the use of computer interfaces which stems from (Gomez et al., 1986). Studies of line-based text editors (Gomez et al., 1986) and hierarchical file systems (Sein & Bostrom, 1989) indicate that novice users with high visualisation ability perform significantly better than those with low ability. Thus, with graphic interfaces such as icons, these users should be better equipped to deal with the cognitive demands of these systems. Gomez et al. (1986) modified the appearance of various interfaces to examine under what conditions users with high visualization ability performed better in transforming mental images of a system. They replaced certain text commands with visual interfaces and reported that the modification resulted in significant performance improvements for that population, i.e. the ones with high visualization ability.

Similarly, in non-computer domains, it has been reported that subjects provided with high visual aids recalled their neighbourhood better than those subjects with low visual aids. These high visual aids also enhanced accuracy in carrying out specific tasks.

Sein et al. (1993) conclude that interface studies suggest two things. Firstly, there is a close relationship between the representation of the system or application by the computer interfaces and the demands placed on the users to form their own internal representations of the state of the system. In the absence of an explicit interface representation, users must rely on their abilities to internally visualise the dynamics of system functioning and the resulting system states. Individuals who have been provided with strong visual interface tools therefore perform better than those who have not. Secondly, interfaces can be modified to increase the users' understanding and performance, either by making the representation more explicit or by presenting it in a form that is more familiar.

In summary, while the development in the interface design has grown in the past decade to include multimedia interfaces and intelligent interfaces, only few EUC studies have included how these interfaces are used in accomplishing given tasks. While these previous studies in EUC have measured the utilisation of interfaces and associated details, most of them have failed to explain why such outcomes were realised in their research environment. Simon et al. (1996) attributed the variation in EUC results to the failure of proper theoretical underpinnings. The research presented in this thesis aims to provide a theoretical foundation for explaining outcomes in terms of interfaces and their influences on EUC training.

Studies that have investigated the management aspects of training

Prior studies in EUC have investigated various management aspects of training. For instance, Filipczak et al. (1996) highlighted the importance of management controls in end user training. They report that about US$7,500 is spent on support costs (in Government organisations) per end user per year on average and that this cost is not measured or managed in many organisations. This high cost has placed training managers under pressure and these managers constantly seek ways to reduce cost and improve performance. One such way is to offer training programs that are efficient and effective in order to justify the training investment.

Another trend reported by Black (1995) was the option of outsourcing some training functions. Black asserts that while larger organisations might outsource their generic training functions, specific training would still be conducted by the organisation. The rationale behind this approach is not one of cost saving, but to ensure that the right type of training is provided to employees. Organisations are keen to provide the right type of training to increase the productivity of their employees.

A study conducted by Guimaraes & Igbaria (1996) assessed user-computing effectiveness in terms of a number of factors such as system utilisation, job effectiveness, attitudes, support given to end users, anxiety and experience. The purpose of the study was to explore how these factors influence the management of EUC. The study concluded that support given to end-users by management is critical to the success of EUC. The study established that management support and control play a vital role in EUC.

Nelson et al. (1995) investigated the relationship between users, tasks and organisational elements with respect to EUC training. They developed a nine-cell matrix to explore the linkages between these three elements. The study, which was conducted in a single large organization, concluded that there was a need for a coherent strategy to link these three elements in order to achieve success in EUC training. The role of management in defining these links is highlighted by Nelson.

Moad (1995), while evaluating the benefits of training investment, stresses the need to involve users in the development of training goals and courses. He adds that management control is an essential component in realising the benefits of training. Harp (1995), while echoing similar thoughts, suggests that training should be linked to the corporate mission to realise maximum potential. Harp claims that such a link will ensure that employees are competent in performing their jobs as a result of the training provided. Harp also recommends a comprehensive needs assessment to establish skill deficiencies in critical areas before training programs are designed.

Barron (1996), while advising on the availability of training dollars to training departments, suggests that trainers need to link every training initiative to a company's strategic agenda. Barron highlights the importance of evaluation of training programs in order to verify the objectives set prior to training. He states that this is essential to maintain the quality of the training efforts. Barron also concludes that it is important to keep the essential training function in-house and certain other tasks can be outsourced, and moreover, that management must provide direction in this regard.

In summary, the management aspects of training are concerned with the involvement and control of training programs in an organisation and have no direct relevance to the proposed study.

Conclusion

It can be seen from the review that previous studies in EUC training have used two types of measurement approaches: quantitative and subjective. The quantitative measurement involved two components. The first component, score, depended on the number of steps involved in performing a task. Certain studies have allocated partial scores while other studies have included penalty scores for wrong answers. The scores were found to be dependent upon the number of steps involved in completing a given task. Additionally, accuracy is also measured in conjunction with score while performing a given task. Accuracy has been measured in terms of correctness of responses for a given task, the number of errors committed and the percentage of errors committed. The second component, the time involved in completing a given task, has been measured using self-reported forms or automated clocks. In subjective measurement, usually a questionnaire was given to obtain self-reported data.

Despite the different ways in allocating scores and time required to perform a task, most studies have agreed that these components are essential in determining training outcomes. The score component is generally used to determine the effectiveness of training outcomes and the time component is used to determine the efficiency of the training outcomes. According to Carrol & Rosson (1995), these two components may be combined to determine the overall performance of users after training.

Some studies have insisted that quantitative measurement alone in EUC training studies is not sufficient. These studies contend that this measurement should be complemented with subjective measurement to capture the users' perception of ease of use with a specific software application. The rationale for this is that ease of use (a subjective measure) plays a crucial role in motivating learners to use a software application. Studies that have taken this approach have established a positive correlation between ease of use and motivation to use a software application. Thus, based on the above discussion, it seems likely that the training outcomes need to be measured in terms of both quantitative and subjective measures.

EUC studies have also investigated the integration of existing knowledge with previous knowledge to derive new knowledge. These training materials have advocated a discovery and active learning approach and have focused on the main issues in order to keep the learner from becoming frustrated. They have also tried to make the learners use the software as soon as possible. It was also found that rich text elaborations in training materials influence understanding and that text elaborations played a crucial role when learners are oriented towards a general learning orientation and not specific goals. The literature reviewed in the education domain reveals that learning can depend on whether information is either in the form of text or in the form of images. Therefore, when training materials are considered for the purpose of information processing, elaborations should be given in both image and verbal forms. Previous studies have established that this style dimension increases the training outcomes of novice users. Despite these findings, however, there is no common agreement among researchers regarding the development of training materials and the applicability of associated training approaches appropriate to training. A few studies in the early 1990s have suggested that learning takes place either by exploring the features of application software or by following instructions given in a step-by-step manner. However, the literature clearly indicates that the issue of suitability of different approaches for EUC training is yet to be resolved.

The reviewed literature also indicates that training materials should be based on the features of the application software itself. These training material features may be classified under two categories: process features and structural features. These two features need consideration in terms of instructional development in order to study EUC training outcomes accurately. The need for the proper construction of training materials using process and structural features is highlighted in several studies.

In terms of interfaces, studies in EUC have taken a "usage" perspective examining how users navigate the system functions based on the interfaces.

Researchers have attempted to extract information on how users understand the functional aspects of the interfaces available in application software packages and how they apply them in performing tasks, for example, functional aspects have been examined by providing a task sheet to users with a number of disjointed tasks.

Another interesting aspect emerging from the literature of EUC is the close relationship between studies that have focused on design and those that have focused on usage. The design studies have emphasised factors such as speed of learning, error rate and speed of use and the studies on usage have measured accuracy and time factors.

Studies that have measured the influence of application interfaces have incorporated cognitive dimensions to explain why specific results have been obtained. The inclusion of cognitive aspects was a direct result of Shneiderman's (1982) assertion that the knowledge content of interfaces consists of both semantic and syntactic details, which are processed by individuals in different ways. It is generally agreed that EUC training covers the semantic aspects of interfaces.

Another aspect that has emerged is the ability of novices to perform better when the interfaces are understood thoroughly. It is argued that interfaces with visual impact, such as icons or menus, better equip novices to deal with the cognitive demands placed upon them by computer systems both in EUC and non-EUC domains. While some EUC research has reported that the ease of use of interfaces is not a major factor in determining training outcomes, studies in the cognitive domain suggested that the ease of use is a determinant factor. It has been suggested that, the assimilation of new knowledge is enhanced and improved by the provision of direct representations facilitated by visual interfaces such as icons. Thus, visual interfaces have distinct advantages over traditional interface styles such as command-based interfaces.

Menu assists users in activating "recognition memory" where visual images of commands are stored. Studies in the cognitive domain suggest that menus reduce the load of remembering command syntax and are therefore attractive to novice users. However, one criticism of menu interfaces is that there are limits to the choices they provide, but the same thing can be said about iconic interfaces.

Many previous studies in EUC have failed to consider the classification of users in their experiments, despite the existence of such classifications. For example, Carrol & Mazur (1986) provided information on her categories of users, but other studies have tended to treat all users as having the same level of knowledge. This anomaly may have caused the propensity for contradicting results in much of the research. Despite the availability of various typologies in EUC, it appears that these typologies are not strictly followed while categorising users in EUC training studies. In the past three or four years new end user categories such as application-based users and construct- based users, and those users with a varying degree of previous knowledge and experience such as beginners, intermediate and advanced have started emerging. These user types need to be considered in EUC studies to accurately categorise end users.

Few studies have highlighted the importance of learning styles and cognitive styles in EUC training even though these concepts have been widely used to investigate individual differences in learning in education. The dominant instrument used to classify learning styles in education appears to be Kolb's learning style inventory, which has been criticised for its face validity. Therefore, any new study should ensure the applicability of learning style instruments. In conclusion, Chapter 2 has provided a review of EUC literature and educational literature to provide a basis for the proposed study. Chapter 3 will describe the research methodology.

CHAPTER 3 – RESEARCH METHODOLOGY

This chapter defines the research methodology for the study. It includes refinement of the initial research framework identified in Chapter 1. This is followed by the research questions, discussion of the variables identified and operationalisation of these variables. The training outcome measures are then discussed and elaborated to facilitate the design of the experimental procedure.

Refinement to initial framework

The framework identified in Chapter 1 provided only the main variables – interfaces, training approaches and categories of end users. With regard to the first variable – interfaces – the majority of previous studies in EUC have considered only icons and command based interfaces and not the treatment of menu interfaces. But the literature review indicates that menus could reduce the load placed on cognitive dimensions while processing information (Johnson & Nemetz, 1998). Therefore, it is possible to assume that menus would yield better performance results. Further, due to the limitations on icons in representing various actions facilitated by computer systems, menus appear to be a natural choice for users who want to navigate the system to perform novel tasks. Therefore, both menu and icon interfaces are considered in this model.

The second variable – categories of end users – consists of basic users and advanced users. While some studies have identified these variables (Carrol & Mazur, 1986; Olfman & Mandviwalla, 1995), the majority of studies in the EUC training environment have not considered categorising users. However, it is evident from research in the education domain (Riding & Cheema, 1991; Sadler-Smith, 1996; Schmeck, 1988), especially in learning and cognitive styles, that user experience plays a crucial role in comprehending the information provided via training materials. Assimilation Theory (Ausubel & Robinson, 1968) has successfully proposed that existing knowledge is integrated with new knowledge in order to process information. This indicates that prior knowledge and experience have a role to play when new information is processed. Further, previous studies have also been questioned for treating users as if they have the same level of knowledge and this has been seen as one of the reasons for their contradictory outcomes. Therefore, this study considers two categories of users – basic and experienced – based on their knowledge and experience. These categories will have an impact on the production of training materials and the consideration of tasks, which is discussed later.

The third variable – training approaches – is derived from the previous studies (Bostrom et al., 1990; Davies et al., 1989; Davis & Bostrom, 1993) and consists of an instruction and an exploration approach. This variable is used to test the effect of instructions on training outcomes. In this study, this variable has been modified to include the construction of training materials and the testing of the impact of training instructions based on instruction and exploration approaches. While previous studies have used arbitrarily constructed training instructions, training design in this study follows the guidelines provided by instructional designers such as Dick & Carey (1990). These guidelines include assessing the experience and level of users prior to the instructional development, and the setting objectives, and also includes introducing task complexity parameters and evaluating training outcomes in a systematic manner.

The model includes a dependent variable – training outcomes, which is made up of a quantitative outcome component and a subjective outcome component. The first component, quantitative, consists of effectiveness and efficiency parameters. Effectiveness is a measure of score and the efficiency is a measure of time. Effectiveness and efficiency measures are derived from the hands-on experiment conducted. The next component, subjective, is a measure of perceived ease of use. Perceived ease of use is measured through an opinion survey.

The refined training framework is shown in Figure 3.1.

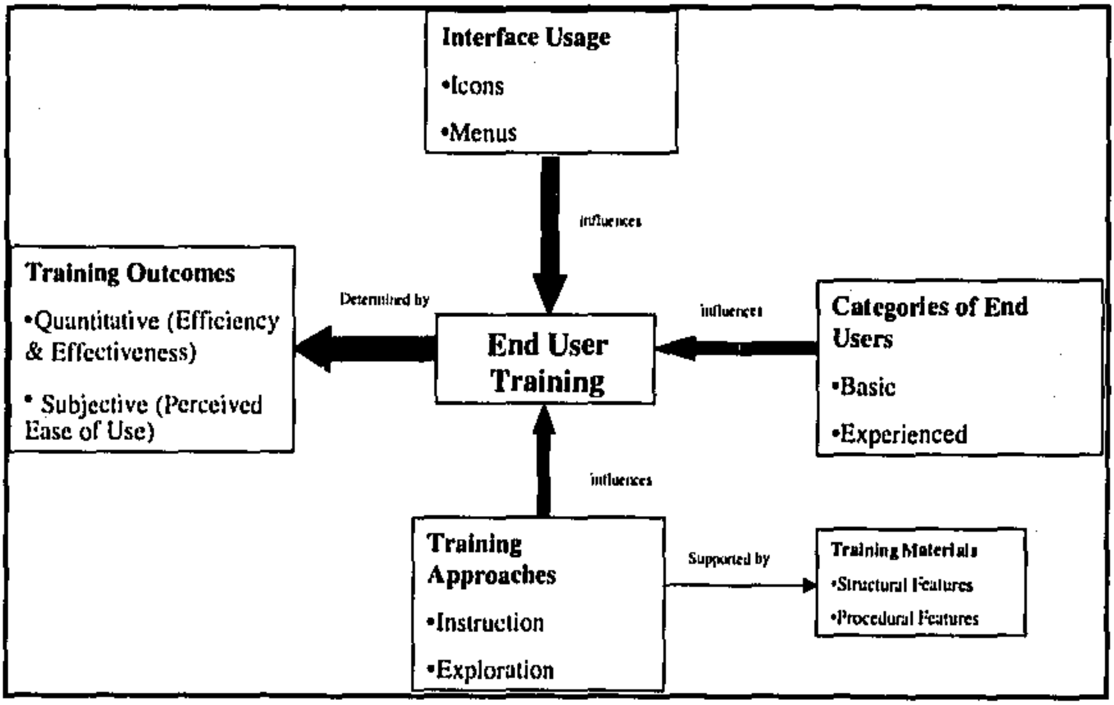

Figure 3.1 Refined Framework

Selection of Application Domain

In this study, the Microsoft Project Management application is considered for a number of reasons. The first reason being that the subjects considered for the study have no exposure to this application. The second reason being, the project management concepts are new to subjects. The relative newness of the application eliminates any bias that can be introduced at the time of experiment. Thirdly, the interfaces available in the project management applications are quite different from that of wordprocessing and spreadsheet applications. The project management applications are not usually found in home applications and hence the exposure to this application from end user point of view is almost not heard of.

As mentioned earlier, it is generally accepted that project management applications are radically different from wordprocessing or spreadsheet applications because of the nature of the concepts involved (Hutchinson & Sawyer, 1996). While wordprocessing and spreadsheet applications etc. can be used without thorough planning, project management applications need proper planning in terms of the allocation of resources. For example, one concept in project management is 'milestones', which is the anticipation of task completion based on the resources available. When multiple variables are involved in a project, estimation of milestone becomes critical for tracking the project schedule. Users have to understand how this is done and how this is implemented in the computer application. Wordprocessing and spreadsheet applications do not have this level of difficulty because the concept of linking various elements of an application is not crucial in these environments.

Additionally, the interfaces in a typical end user application, such as wordprocessing, are readily understood because of familiarity. In a modern desktop environment, many of these interfaces are used on a daily basis by end users. Interfaces in project management software, on the other hand, are less familiar and difficult to comprehend by end users because of their specific meanings and it is expected that users in this study will need to learn the meaning of these interfaces in order to complete tasks successfully. Therefore, this study uses a project management software application to test the impact of interfaces when learning.

It is possible to execute some operations of project management using spreadsheets. However, when it comes to tracking a project, spreadsheets do not provide all the functions that are needed in a project management environment. Further, instructions provided through spreadsheets for project management are quite different from those of the project management software itself. Therefore, to avoid any bias from prior knowledge, 'Microsoft Project'[20] has been chosen for this study rather than spreadsheet software such as 'Excel'.

Furthermore, this study was conducted in a tertiary setting where Microsoft Project is available to students in computer laboratories, and where training could be conducted with minimal administrative overheads. Therefore, this application was chosen for the experiment purposes. This is reflected in the following research questions.

Research questions

The literature review and refined research framework suggest that EUC training outcomes are influenced by interfaces, training approaches and categories of end users. The following research questions are therefore raised:

How do different types of interfaces affect training outcomes for project management applications?

Studies in EUC have found that interfaces play a crucial role in determining training outcomes. As mentioned previously, while icon interfaces have been investigated, little information is found in EUC studies regarding menu interfaces. Moreover, conflicting results have been demonstrated with regard to the advantages of icon interfaces. While studies in education have successfully established that icon interfaces have a positive impact on learning outcomes because they can portray the computer system in a manner which users can comprehend, they have also indicated that menus reduce the cognitive demand placed on the users. In this research, the usage of two interfaces – icons and menus – will be examined in a project management software environment. In this study, users will be asked to nominate

[20] In this study, Microsoft Project version 98 was be used under Windows 98 operating system.

their interface preference based on the training provided in order to accomplish tasks to determine the influences of interfaces on training outcomes.

How do different approaches to training affect training outcomes for project management applications?

Studies in EUC have established that different training approaches have an influence on training outcomes (Bohlen & Ferrat, 1997; Bostrom et al., 1990; Davis & Bostrom, 1993). However, there is no firm agreement as to the best approach for EUC training. This study will investigate the impact of two training approaches – instruction and exploration – on users' learning outcomes using training materials prepared for project management software application learning.

Prior studies (Bohlen & Ferrat, 1997; Bostrom et al., 1990; Davies et al., 1989; Davis & Bostrom, 1993) have allocated users to particular interface types and instructions have been prepared in advance to suit these interfaces. As mentioned in the previous chapter, this has resulted in conflicting training outcomes. One reason appears to be the forced interface type on subjects. Users conduct tasks using interfaces such as icons and menus and develop a preference. Similarly, users develop a preference for conducting tasks in an orderly step-by-step fashion or taking short cuts or by exploring application functions (especially in novel situations). Therefore, users who were forced to follow an interface treatment irrespective of their preference might behave inconsistently. To avoid this effect, this research question will examine the influences of training outcomes while allowing subjects to nominate their preference for a training approach suitable to them based on the training provided.

What is the influence of prior knowledge and experience of users on training outcomes for project management applications?

Many EUC studies have been criticised for their poor population selection or sampling procedures (Ruble & Stout, 1993; Simon et al., 1996). Users' prior knowledge and experience have often not been taken into consideration and as a result experimental research[21] in this area has not been well organised (Sein & Bostrom, 1989). While EUC studies have recognised the fact that prior knowledge is essential

[21] The experimental research method is discussed later in Research Method section in this chapter.

to process the information given to reach advanced stage of training (Carrol et al., 1987), very few attempts have been made to test this aspect. This study tests the influence of prior knowledge and experience on training outcomes. Therefore, users have been categorised into basic and experienced users. This categorisation was determined by a set of self-reported questionnaires.

How do different learning styles affect training outcomes for project management applications?

Previous studies have indicated that learning preferences have an influence on training outcomes. Others have recommended that future EUC studies ascertain learning style preferences prior to the commencement of experiments as these styles serve as predictors of training outcomes (Chin, 1984; Fryer, 1991). Studies in the education domain also support this concept. To incorporate the consideration of different learning styles, Honey & Mumford's (1992) instrument has been used to ascertain user learning preferences. The choice of this instrument was based on its widespread use in training environments and its statistical validity. Further, Honey & Mumford have provided an algorithm for determining respondents' relative strengths in order to determine their learning style preference and this algorithm is well tested and accepted by training communities in Europe.

This study does not attempt to see the influences of learning styles at various points of training and experiment. The treatment of learning style preferences is restricted in order to measure only the influences of learning styles on training outcomes because there is research to support the claim that the learning style of an individual can change during the course of learning. However, these findings arise from education and not from short training programs. This study will aim to verify the claim made by previous studies that learning style is a predictor of training outcome in short training programs by using Honey & Mumford's instrument because this instrument has been proved to be valid in training environment.

Discussion of research variables and hypotheses

The research model defines the target system based on two types of computer interfaces (i.e. icons and menus), two different training approaches (i.e. instruction and exploration) and two categories of end users (i.e. basic and experienced).

Training outcomes in this study will include quantitative[22] outcomes (effectiveness and efficiency) and subjective outcomes (perceived ease of use). These variables are discussed in detail in the following sections.

Training Outcomes

While the literature has provided information on a number of ways outcomes are determined in EUC studies, it appears that there are two major categories – quantitative and subjective. The quantitative methods use a measurement scheme of numeric values and in EUC studies scores for accuracy and time components have been common quantitative measures. User opinions have been extracted using subjective approaches. Instruments such as survey forms and questionnaires have been used to obtain user opinions. EUC studies have provided a very clear distinction between these two approaches.

In this study, the quantitative approach is used to determine the training outcomes effectiveness and efficiency. Effectiveness is measured in terms of scores obtained in completing a given task. Some studies in EUC have calculated scores based only on keystrokes (Davies et al., 1989; Davis & Bostrom, 1993) and some others have calculated based on errors committed as well (Olfman & Bostrom, 1991; Sein & Bostrom, 1989). However, the scores calculated in these studies involve a manual process and due to this, subjective bias could have been introduced. Therefore, to arrive at an accurate score, the subjective bias needs to be minimised or eliminated. This study will aim for the elimination of subjective bias at the time of capturing keystrokes.

In addition, in order to arrive at an accurate score, aspects such as the number of errors committed, the number of times a user has reverted back to a previous step either because an error was committed or because the user was not sure whether a correct action had been taken need to considered. This study will incorporate a scoring scheme that will include aspects of errors, backtracks etc in order to determine accurate scores.

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[22] Quantitative outcomes measure responses such as keystrokes, errors etc based on an experiment conducted; subjective outcomes measure perceived ease of use via a survey questionnaire where users provide their opinion for questions on a Likert scale.

Training outcome efficiency was calculated based on the time taken in performing the given task. Prior studies (Olfman & Mandviwalla, 1995; Sein et al., 1993) have used various methods such as asking users to estimate time spent in completing tasks, using manual clocks, using automated logs etc. Only few studies (Bohlen & Ferrat, 1997; Carrol & Mazur, 1986) have used computer clock to automatically log the time spent on the experiment. This study will incorporate a procedure that will enable capturing the time component using a computer clock to determine the time factor for efficiency.

The subjective component in this study measures ease of use. This motivational factor is measured using a questionnaire. Previous studies (Davies et al., 1989; Davis & Bostrom, 1993) have recommended that this ease of use measure component be determined to fully study the effects of effectiveness and efficiency because training will be effective only if the users found the system to be easy to use. This study accepts the recommendation that ease of use be considered and uses instruments used in prior studies with some modification to suit this study.

Computer interfaces

Interfaces can present a model of a computer system either directly or indirectly (Davis & Bostrom, 1993). With direct representation, the form of objects such as icons to be manipulated is understood immediately. For example, a printer icon represents a printer and users can derive the meaning without any ambiguity. If the interface assumes an indirect form, such as Page Setup, then users activate the interface to perform a command. Usually the indirect form is provided by a menu interface. This study focuses on icons and menus because they represent direct and indirect forms of interfaces and are predominantly available in end user applications these days.

One would expect icons to facilitate more meaningful learning than menus because icons can portray the meaning of interfaces easily. The fact that icons provide anchoring concepts[23] and give users the opportunity to work directly with those concepts suggests that icons have a unique capacity to reinforce and clarify the

[23] Icons facilitate understanding concepts based on their visual representation. Users store these visual images in their cognitive system and retrieve the concepts whenever the images are seen. Further, anything similar to the visual representation helps the user to retrieve the concepts. Hence the term 'anchoring'.

relationships between pre-existing knowledge in long-term memory and knowledge of a new application software package (Benyon et al., 1999). The expectation is that icons would be more effective in performing basic tasks. However, some studies suggest that menus are more effective in novel tasks because they help the user to navigate the system to its depth by using hierarchical[24] features (Tang, 2001). This would help users to realise situations that are not directly represented by interfaces. In addition, menus can represent more functions of a system whereas icons cannot provide more functions because of their limitations in representing these functions via a symbol. It is also difficult to argue which interface type is superior in terms of performance. Furthermore, the operations of these two interface types are radically different from each other (Shih & Alessi, 1994). Icons have a point-and-click type operation and menus have selections from a set of options with provision for navigation. These two interface designs demonstrate different ways that users interact with systems (Tang, 2001). Although some comparisons had been made of icons and command-languages (Davis & Bostrom, 1993), surprisingly little attention has been paid on the use of menus or the impact of different interfaces on learning outcomes in EUC training studies. This outcome is stated in null form in hypothesis H1.

H1: There will be no difference in quantitative training outcomes between the subjects who preferred icons and those who preferred menus.

Davies et al. (1989) suggest that the acceptance of information technology and its ultimate use are influenced in part by how easy to use the technology. To determine the long-term success of an application, factors that affect ease of use may be of particular interest. Given that factors such as interfaces can contribute to the ease of use, introducing systems with icons and menus may be one way to enhance this perception (Dix et al., 1998). Icons provide a means to work with the applications directly and some users may perceive icons as superior in terms of ease of use. Conversely, users who are familiar with systems may perceive menus superior in terms of ease of use. Hypothesis H2 states this outcome in null form.

[24] Menus are based on hierarchical structures. For example, users have to access the 'file' menu to reach features such as 'save'. This is referred as a hierarchical feature.

H2: There will be no difference in subjective training outcomes between the subjects who preferred icons and those who preferred menus.

Training approaches

Evidence can be drawn from previous studies in EUC that exploration training is more effective than instruction training in facilitating the integration of existing knowledge with new knowledge (Davis & Bostrom, 1993). This study compares the impact of exploration and instruction approaches on training outcomes.

To facilitate the successful integration of knowledge, learners should be allowed to use the training materials in different ways (Olfman & Mandviwalla, 1995). While instruction learning facilitates a step-by-step approach, exploration learning facilitates a trial-and-error approach. Users who are not familiar with specific aspects of application software would most likely prefer an instruction approach. However, users who possess the 'hands on' qualities would most likely prefer an exploration approach.

Further, due to cognitive differences, it may not be possible to assume that users will understand training materials uniformly (Olfman & Mandviwalla, 1995). Depending upon their information processing capabilities, certain users will benefit from an instruction approach and certain other users will benefit from an exploration approach as they like to explore the functions of a given system to develop their understanding.

However, it may also be difficult to accommodate every aspect of training into training material. Users may encounter a situation for which it may be difficult to provide instructions and for which they have to integrate their existing knowledge and knowledge acquired during training to solve some problem. Therefore, it is difficult to predict which training approach would benefit users with certain tasks.

The propositions of Assimilation Theory[25] (Ausubel & Robinson, 1968) would enable one to predict that the participants with exploration training would

[25] Assimilation theory has been discussed in Chapter 2 – Literature Review.

perform better in far-transfer tasks[26] than those who receive instruction-based training. On the other hand, instruction-based training would be expected to yield better results in a situation where participants simply need to retain the instructions presented during a training session.

In this study, users are allowed to use both sets of training materials – instruction and exploration. Once training is completed, users nominate their preference to training approach. This approach is recorded as users' preferred training approach for the experiment and users are subsequently classified as instruction-based subjects and exploration-based subjects in order to differentiate training outcomes. These outcomes are expressed in the form of null hypotheses in H3 and H4 to address the second research question.

H3: There will be no difference in quantitative outcomes between the instruction-based subjects and the exploration-based subjects.

H4: There will be no difference in subjective outcome between the instruction-based subjects and the exploration-based subjects.

Categories of end users

The literature claims that end users' prior knowledge has an impact on learning outcomes (Carrol & Mazur, 1986; Edmonds et al., 1994). However, substantive evidence is not available in EUC training to justify this claim because very little experimental research has been done to discover whether end user training outcomes can be correlated with users' prior knowledge. Clearly, if training outcomes are affected by prior knowledge, then this should be considered when training end users.

Some prior studies (Carrol & Mazur, 1986; Mayer, 1981) in EUC have classified users as basic, intermediate and advanced based on either knowledge or experience, but not both. Education studies have asserted that knowledge and

[26] The term 'far transfer' is used to indicate that users need to dig their memory to retrieve information that is not readily available in short-term memory. The information stored in the long-term memory is transferred to short-term memory and then this information is used in processing tasks.

experience are positively linked. Therefore, it is essential to consider users based on both knowledge and experience and this is especially true in IT applications where theoretical knowledge is applied to applications to complete a given task which constitutes one's experience with a particular application or system. In this study, users will gain some understanding of project management through training, and this conceptual knowledge will then be implemented while performing training tasks using Microsoft Project. While performing tasks, their prior knowledge and experience in the general field of computing or IT will facilitate them to apply those generic concepts in a project management environment which is relatively new to them.

While it is possible to distinguish basic users from advanced users based on the type of operation performed using an application, it is difficult to classify intermediate users because the specification used in EUC research appears to overlap both basic and advanced in terms of functions performed by these users (Hutchinson & Sawyer, 1996). Therefore, this study uses only two types of users based on both knowledge and prior experience. These are basic and advanced. However, due to the relative newness of the project management application that will be used in this study, it is difficult to predict whether advanced users will have any distinct advantages over basic users when their only knowledge and experience is gained through a limited training program[27]. Despite the claim by Assimilation Theory that prior knowledge helps in integrating new concepts, the time taken to integrate and then assimilate such knowledge in EUC is not yet well understood and may depend upon the individual user qualities. It is, therefore, difficult to state whether a specific type of user would perform better in a situation which is radically new to him/her. To address the third research question, the following null form of hypothesis is generated and stated in Hypotheses H5 and H6.

H5: There will be no difference in quantitative measurement of training outcomes between basic level subjects and advanced level subjects.

[27] This study considered training programs of 45 minute duration only and this is discussed later in this chapter.

H6: There will be no difference in subjective measurement of training outcomes between basic level subjects and advanced level subjects.

Learning Style Preferences

Some prior studies in EUC indicate that learning style preference is a consistent predictor of training outcomes (Bostrom et al., 1990; Sein & Bostrom, 1989). While Sein & Bostrom (1989) have established the importance of individual differences, Bostrom et al. (1990) have established the importance of learning styles as a component of individual difference in end user training. Bostrom et al. (1990) mention the following in support of this construct in end user training studies:

> A very consistent pattern of findings suggests that a case can be made for the learning style construct as a significant factor that influences the learning of EUC software (p. 107).

While learning style preference is investigated to some extent in EUC training, there is no conclusive evidence as to which preference leads to better performance (Sein et al., 1993). Further, the number of studies that have investigated learning styles in EUC are very limited and thus the assertions made by these studies cannot be considered conclusive.

One major problem to emerge from studies that have investigated learning style preferences in EUC is the use of Kolb's Learning Style Inventory (LSI) which has been criticised for its lack of applicability in EUC training (Ruble & Stout, 1993). Therefore, there is a necessity to replicate what has been done in prior studies, in terms of learning styles, using instruments that are appropriate and suitable to ascertain learning style preferences.

Further, prior studies (Olfman & Bostrom, 1991; Simon et al., 1996) that have investigated learning styles have used training programs spanning a few hours. The applicability of their impact in short training programs lasting about 45 minutes[28], which is the time devoted to train users in this study, is yet to be determined. While EUC training studies (Bostrom et al., 1990; Davies et al., 1989; Sein & Bostrom,

[28] In this study, training is provided for 45 minutes only and this is covered in research design section.

1989) clearly indicate the availability of four learning styles – activist, theorist, pragmatists and reflectors – it can be said that the impact of these four styles on training outcomes is not fully conclusive. As a result, this study introduces a learning style variable in order to measure its effect on EUC training outcomes. Due to inconclusive evidence from previous studies, it is difficult to predict which learning style preference would become a predictor of training outcomes yielding better results. Thus, it is difficult to set the direction while stating the hypothesis. Therefore, to address the fourth research question, the following null form hypotheses were formulated.

H7: There will be no difference in quantitative measurement of training outcomes due to learning style preferences.

H8: There will be no difference in subjective measurement of training outcomes due to learning style preferences.

Interactions between interfaces and training approaches

The exploration training approach requires users to learn by trial and error with problem-solving tasks (Davis & Bostrom, 1993). This is contrasted with the instructional training approach where users are given step-by-step instructions. The two interfaces, graphic icons and menus respectively, provide the user with different information on the structure of an application. Menus demonstrate the hierarchical structure of an application and provide for progression and regression through layers of this structure. This enables errors to be more easily reversed. With menus, decisions need to be made on the appropriateness of one selection over another. With icons, on the other hand, users simply click to directly operationalise a function, so their understanding of the application will not be the same as with the use of menus.

It is possible that the trial and error tasks required by the exploration training approach are facilitated more by menu interfaces than by icon interfaces because they provide the user with a greater understanding of the hierarchical structure and allow for progression and regression through this hierarchy. Conversely, the instruction approach may be enhanced by the use of icons which simplify the step-by-step tasks by eliminating the choices inherent in menu selection. The possibility of these interactions are addressed in the following null hypothesis:

`H9: There will be no difference between icon-based subjects opting exploration training and other interface/training subjects in terms of quantitative measurements of training outcomes.`

It is also possible that the qualitative measure, ease-of-use, be affected by an interaction between training approach and interface. Some users might find icon interfaces easy to use because of the absence of choices and their apparent meaning, whereas other users might consider menus easier to use because they can move backwards and forwards through the application and utilising its deep navigational facilities. Users' own learning style preferences may determine these perceptions. Moreover, menu interfaces may be considered easier to use for the trial and error tasks of the exploration training approach because they provide deeper understanding and more flexibility. Whereas icon interfaces might be considered easier to use with step-by-step tasks of the instruction training approach because the direct operationalisation of the function simplifies the procedure further for the user. The effect of the possible interaction between interface and training approach on the qualitative measure ease-of-use is expressed in the following null hypothesis:

`H10: There will be no difference between icon-based subjects opting exploration training and other interface/training subjects in terms of subjective measurements of training outcomes.`

Interactions between interfaces and categories of users

The combination of computer interfaces and categories of users may have an influence on training outcomes because users with prior knowledge of how to use interfaces may apply this knowledge to use them better in a relatively new situation (Carrol & Mazur, 1986; Sein et al., 1993). In this case, the prior knowledge of the advanced category may result in greater skill with and greater preference for menu interfaces. That is, advanced users may be able to obtain better training outcomes because of a deeper understanding of the application, or one that is provided by menu interfaces. Basic users, on the other hand, may perform better using icons as their limited prior knowledge may not equip them with the skills or confidence to make menu selections. They may also prefer the icon interface because choices are eliminated. These possibilities are accommodated in the following null hypotheses:

H11: There will be no difference between the icon-based subjects having basic level of knowledge and other interface/level subject in terms of quantitative measurements of training outcomes.

H12: There will be no difference between icon-based subjects having basic level of knowledge and other interface/training subjects in terms of subjective measurement of training outcomes.

Interactions between training approaches and categories of users

Outcomes may also be influenced by the interaction between training approaches and categories of users (Olfman & Mandviwalla, 1994). That is, the interaction with tasks based upon a training approach is partly determined by users' prior knowledge. This is because advanced users with prior knowledge may respond more favourably to challenging tasks using the exploration training approach as they are capable of manipulating novel situations based on their prior knowledge, which is in turn further facilitated by the exploration approach. The basic category, however, may respond better to the step-by-step instructions of the instruction training approach as it does not require the level of ability that problem-solving tasks do. In addition, when basic users are confronted with novel tasks, depending upon the training approach, they may be able to show improvement. For instance, a basic user having opted for an exploration approach, may be able to explore the application to complete a given task. The exploration approach may be considered easy by advanced group because this combination provides ways in which the application can be explored when compared to the basic users and instruction combination in novel tasks.

However, due to lack of information in prior studies about the interaction between training approaches and level of knowledge of users, it is difficult to set the direction to ascertain which combination is superior. While previous studies have established that level of knowledge play a significant role in determining training outcomes, contradictory results have been obtained in these studies (Carrol & Mazur, 1986). This can be attributed to the non-uniform categorisation of users based on their knowledge. Based on the above, two hypotheses address the possibility of these effects in null form in H13 and H14.

H13: There will be no difference between instruction-based training to participants in the basic category and other training/level subjects in terms of quantitative measurements of training outcomes.

H14: There will be no difference between instruction-based training to participants in the basic category and other training/level subjects in terms of subjective measurement of training outcomes.

Based on the above, the refined research framework can be redrawn to map the hypotheses as depicted in Figure 3.2.

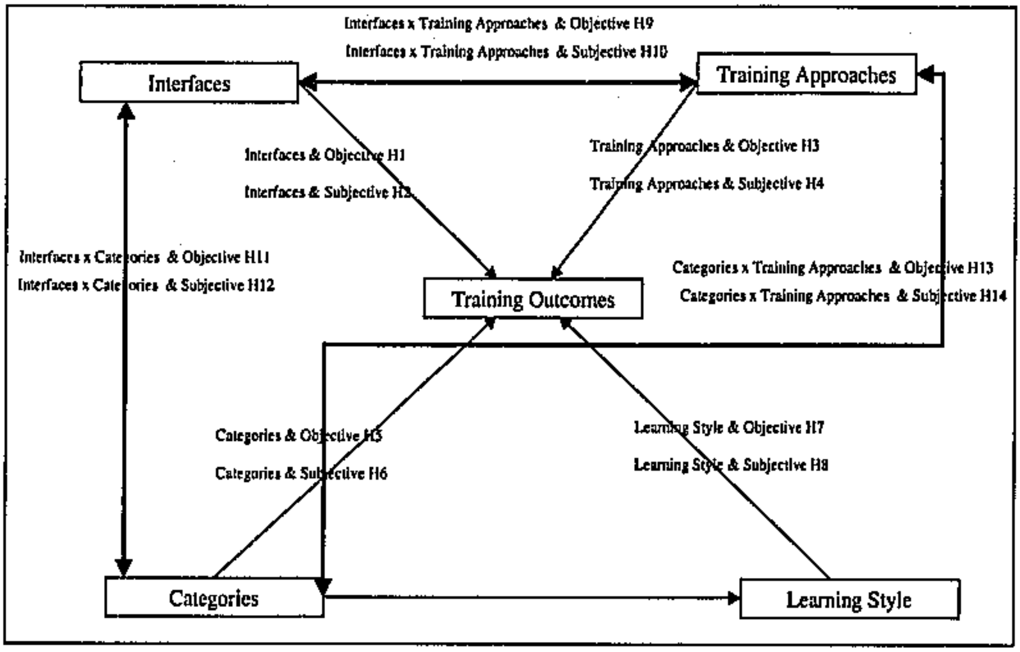

Figure 3.2 Hypotheses Mapping

Research Method

Research in information systems (IS) can be broadly classified into studies based on positivism and interpretivism (Remenyi et al., 1998). Positivist research studies typically use quantitative measures and interpretivist use qualitative methods. In order to select a research method, Neuman (1991) suggests that it is essential to classify research activities into component stages to identify the research framework and hence the methods needed to conduct the research. Taking this into account, this study classified various activities into component stages such as selection of subjects, preparation of training materials, pilot study and experiment.

Another dimension to research is the 'purpose' dimension. Babbie (1989) and Neuman (1991) argue that research can be described as exploratory, descriptive or explanatory depending on its purpose. Among these three, explanatory research attempts to answer the question of why things happen and usually employs methods that allow for a very high level of control such as experimentation and the use of scientific methods (Remenyi et al., 1998). These experiments are usually conducted in a laboratory and are intrinsically positive in nature (Remenyi et al., 1998). Experiments generally rely on observations which will be reduced to numbers and which will be structured in such a way that they can be replicated. However, this is an "illusory" concept because participants of an experiment are rarely available when the experiments are repeated. Experiment is designed to answer specific questions. Laboratory experiments use quantitative techniques of evidence analysis to deliver answers to highly structured research questions.

The literature review indicates that EUC studies have predominantly used an experimental approach with hands-on tasks. For instance, studies conducted by Bohlen & Ferrat (1997), Davies et al. (1989), Davis & Bostrom (1993), Sein et al. (1993) and Olfman & Mandviwalla (1994) have used an experiment to find the causal relationship of variables. These experiments were conducted in laboratory settings where subjects used computers to perform hands-on tasks. An exception to this was Olfman & Mandviwalla (1994) who used a paper-and-pencil method to test subject's skills because his pilot subjects expressed concern about the time factor when completing the tasks using computers.

In addition to the quantitative methods, this study employs subjective methods. This has been done to ascertain the level of satisfaction and ease of use and was as expressed by users using a survey/questionnaire instrument. Previous studies (Davis, 1985; Davis & Bostrom, 1993) have emphasised the fact that users who are satisfied with a training environment will consider it easy to use. Therefore, ease of use would provide an impetus to users to use the application and hence enable the measurement of this motivational factor. This study, therefore, has evaluated user opinions in terms of ease of use using a questionnaire.

Based on the above, this study will employ an experimental approach to measure the objective outcomes – effectiveness and efficiency, and a survey approach to measure the subjective outcome – perceived ease of use.

The outcomes efficiency, effectiveness and ease of use are dependent upon interfaces, training approaches and categories of users. Therefore, the training outcomes are referred in the study as dependent variables and interfaces, training approaches and categories of users are referred as independent variables. The variables used in this study are shown in the following table:

Table 3.1 Table of study variables

Variables	Operational Measure
Dependent Variable[29]	
Effectiveness	Function of (total strokes, icon access, menu access, dialogue box intercation, errors, backtracks)
Efficiency	Function of (time, correct strokes)
Ease of use	Questionnaire using a Likert Scale (Disagree to Agree) Instrument based on Davies et al. (1989)
End User Satisfaction	Questionnaire using a Likert Scale (Disagree to Agree) Instrument based on Igbaria (1990)
Independent Variables	
Interface type (user preference, selected by users after training prior to experiment)	Icon (coded "1") Menu (coded "2")

[29] page 118 provides more details

End user category (knowledge & Experience determined by two questionnaires)	Basic (coded "1") Advanced (coded "2") Instrument based on Bohlen & Ferrat (1997) and Doll & Xia (1996) for knowledge and Alloway & Quillard (1983) and Igbaria (1990) for experience
Learning style preference (determined by a questionnaire, coded using a Visual Basic Program)	Activist (coded "1") Reflector (coded "2") Theorists (coded "3") Pragmatists (coded "4") Instrument based on Honey & Mumford (1992)
Training type (user preference, selected by users after training prior to experiment)	Instruction (coded "1") Exploration (coded "2")

It should be noted that both laboratory experiments and survey methods have advantages and disadvantages. Experiments provide a basis for isolating causal factors and control conditions in order to control one or more variables for hypothesis testing. Laboratory experiments rely on highly structured research questions. A requirement with experiments is the rigor needed to execute the experiment schedule and the associated controls. Further, while the survey method is easy to execute (when compared to an experiment), sampling is a critical issue (Zikmund, 1994). If samples are not selected properly, bias will be introduced in responses. Further, 'respondent error' will be introduced if the responses are not truthful (Remenyi et al., 1998). Based on the above points, in this study, every action has been taken to validate the survey instruments in terms of their suitability, appropriateness and usefulness. The adverse influences of these approaches are discussed in the Limitations Chapter.

Development of Instruments

The development of instruments in this study consisted of a number of phases. Initially the study identified suitable instruments such as questionnaires and survey forms from previous studies. Once these were identified, the suitability of these instruments was assessed. For example, to assess the prior knowledge of subjects, Questionnaire 1 was derived from suggestion given in a previous study (Bohlen & Ferrat, 1997). However, when the questionnaire was assessed for suitability, it was found that certain questions were not appropriate to this study and these questions were eliminated. Additional questions on project management were also added to accurately determine the level of knowledge in this questionnaire. Once these were incorporated, the instruments were sent for peer review. Experts in questionnaire design and others who have experience in EUC training conducted peer review of instruments used in this study. Upon satisfactory peer review, ethical clearance was obtained. Then a pilot study was conducted to assess the validity of these instruments, their applicability and the time needed to complete them etc. Finally, experiment was scheduled. These procedures were introduced to ensure that there is no subjective bias in the study and the experiment could be executed as per a predefined plan. This is explained in the following paragraphs.

To conduct the study, five questionnaires and a set of training materials were developed. The first two questionnaires were used to classify users, the third questionnaire to ascertain learning style preferences and the remaining two questionnaires to measure satisfaction and ease of use respectively, after training. Other training outcomes, effectiveness and efficiency, were measured using online log of subjects' work, which is discussed under the section 'Pilot Study' in this chapter. The following sections detail the development of these instruments.

1. Preparation of questionnaires

Questionnaire I - Familiarity of Computer Terms

This questionnaire obtained information from the subjects about their familiarity with computing terms. Bohlen & Ferrat (1997) claim that familiarity with computing terms is one indication of knowledge and they used a questionnaire to ascertain this. This study used Bohlen & Ferrat 's (1997) suggestions as a basis for the first questionnaire. The questionnaire items were derived from Doll & Xia (1996). The original questionnaire items (12 items) tested subjects computing knowledge in a specific application such as spreadsheets. The original questionnaire items tested subjects' knowledge in the application such as merging cells. Further, the original questionnaire was statistically validated prior to the averaging process[30]. In this study, the original questionnaire items were reviewed and then modified to reflect the nature of this study. For instance, to reflect the total training environment, items on Windows operating systems and Project Management were introduced in the modified questionnaire. This has resulted in the original questions being modified to

[30] Opinions expressed by subjects were averaged for the purpose of data analysis. Statistical validity is discussed later in pages starting from 124.

include 14 questions in order to determine participant's familiarity and exposure to these particular concepts. The first questionnaire consisted of 14 questions and the subjects filled in a Likert-type scale, ranging from 1 (know nothing) to 5 (know a lot). The modified questionnaire items were distributed among peers and students (who did not participate in the experiment) to assess the validity and appropriateness of the questions. According to Amoli & Farhoomand (1996), the process of adding additional items to an existing instrument and then validating the same for appropriateness and relevance is an accepted process. This study has followed such a process.

The first questionnaire tested the familiarity of computer terms by users to identify their familiarity with computer software and hardware related terms[31]. The questions focused on three specific areas of familiarity: Operating systems and operations, application software, and generic operations. The questions were chosen after appropriate peer-review[32] to ensure that questions in fact measure users' familiarity of computing terms. Subjects who are not familiar with certain terms such as Windows 95 and Internet Browsers were considered to be computer illiterate and eliminated from the study. The Questionnaire is included as Appendix 2.

Questionnaire 2 - End User Computing Sophistication

This questionnaire was based on Simon et al. (1996) who argued that, in order to determine the experience level of end users, it is important to extract their level of computing sophistication in addition to their knowledge. Prior studies in EUC have determined level of computing sophistication from application usage, operational usage, intensity of use and their purposes of use. To extract the level of usage sophistication, this study considered four major criteria: (i) type of application usage, (ii) mode of operation, (iii) intensity of usage and (iv) usage purposes. A new questionnaire was developed based on one by Alloway & Quillard (1983) for the first three criteria and on Igbaria (1990) for the last criterion. The questionnaire used different scales to ascertain user knowledge. The first criteria, type of application, used a percentage scale to determine percentages of activities performed by users.

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[31] The items on the questionnaire were averaged for data analysis purposes.

[32] The peer review process is further explained in page 102.

The second criteria, mode of operation, used an optional box where users placed a '✓' or a '×' to indicate their options. The third criteria, intensity of use, used a scale similar to that of mode of operation. The fourth criteria, usage purposes, used a Likert-type scale ranging from 1 (No extent) to 5 (Large extent).

For the data entry purposes, The questionnaire items were assigned with numerical values ranging from 0 to 5 for the usage frequency items. The usage purpose questionnaire items were based on a 5-point Likert scale from 'No extent' to 'Large extent'. These items were averaged to arrive at a single value. As mentioned earlier, any value over 3.5 is considered as advanced level.

According to Guimaraes & Igbaria (1996), previous studies in EUC have measured system utilisation based on actual daily use of the system and application areas. Studies in EUC have measured daily usage of the system by asking users to indicate the amount of time spent on the system per day (Lee, 1986). This study also follows similar approaches. Further, the questionnaire was peer-reviewed by students and colleagues in a tertiary setting for relevance and appropriateness.

In the context of this study, one might question the appropriateness of using this instrument on both basic and advanced level users because basic level users may not have the necessary computing exposure, especially in an industry or work setting. The subjects in this study comprise of both commencing students and mature age students enrolled in a computing award. While certain subjects might be experienced in computing, their usage level needs to be ascertained because this is also a key element (in addition to knowledge) in determining their category such as basic or advanced. This is because one of the proposition in the thesis is that both knowledge and experience of end users help to attain better training outcomes. The first component of the questionnaire determines the level of sophistication and the subsequent components determine the level of usage to determine total experience. While commencing students in tertiary institutions might be limited by constraints, mature-age students (who were also employed in local industries) would be able to fill-in many components of the questionnaire.

Further, the questionnaire was peer-reviewed for its appropriateness and suitability by experienced staff in the academic sector and the statistical significance of the pilot-test established the content-validity of the questionnaire. This has provided the legitimacy to the use of the questionnaire in this study. The questionnaire is included as Appendix 3.

Questionnaire 3 - The Learning Style Questionnaire

This study used the Learning Style Questionnaire developed by Honey & Mumford (1986) to extract four learning style preferences. The questionnaire consisted of 80 statements and users either agreed to a statement in the questionnaire by placing a tick or disagreed by placing a cross. There was no right or wrong answer and responses to the statements indicated the preferred learning style. This questionnaire is included as Appendix 4.

Questionnaire 4 - End User Satisfaction

The 'End User Satisfaction' questionnaire was adapted from Igbaria (1990) and consisted of 12 questions based on a Likert type scale, ranging from 1 (Strongly disagree) to 5 (Strongly agree). The questions addressed the training environment, information presented in the training materials and the accuracy of the information. The questionnaire was modified by changing terms in the original questionnaire to reflect this particular study[33]. Questionnaire 4 is included as Appendix 5.

Questionnaire 5 - Ease of Use

The questionnaire to measure ease of use was adapted from Davies et al. (1989). The original questionnaire which consisted of only 4 questions, was expanded to include 28 questions over five sections: (i) learning to use computers (5 questions), (ii) becoming skilful in using computers (5 questions), (iii) getting work out of computers (5 questions), (iv) operating computers (5 questions) and (v) using training materials (8 questions). The expansion includes new questions to capture information about the overall training environment in addition to specific issues of project management. The questions aimed to capture the perceived ease of use of the operating system, the project management software application and the training material. Users responded to the statements using a Likert type scale ranging from 1 (disagree) to 5 (agree). The questionnaire items were averaged for data analysis.

This questionnaire measured the perceived ease of using a system based on the training provided. A number of studies have used this measure to assess the attitudes

[33] This questionnaire was discarded later as the details measured only the training environment and not the variables of the study.

such as ease of use (Bohlen & Ferrat, 1997; Davis, 1985; Davis & Bostrom, 1993; Guimaraes & Igbaria, 1996). The purpose of using the questionnaire in this study was to determine the 'degree to which a person believes that using a particular system would be free of effort (p.71)' (Davis & Bostrom, 1993). While the first four components – learning to use computers, becoming skilful at using computers, getting work out of computers and operating ch computers – resulted from the suggestions provided by Davis & Bostrom (1993), the fifth item – using the training materials – was a direct result from the suggestions provided by Guimaraes & Igbaria (1996), who stated that the ease of use experienced in using a computer system based on computer training provided would influence users' subsequent behaviour towards it. The specific reason for measuring the perceived ease of use in this study was to determine the extent of the relationships between ease of use, interface and training combinations in the given training environment[34]. As in previous questionnaires, the items were peer-reviewed for relevance and appropriateness. The questionnaire is included as Appendix 6.

Once the questionnaires were prepared, they were sent for peer review[35]. Two independent researchers reviewed the questionnaire to ensure the validity and appropriateness of the question items. The purpose of this peer review was to eliminate any bias introduced by the researcher. Further, guidelines in instructional design (Dick & Carey, 1990; Edmonds et al., 1994) suggest that it is important to establish appropriateness of instruments that measure outcomes using summative or formative evaluation methods prior to the commencement of preparation of training materials. In this study, questionnaire 4 (satisfaction) and questionnaire 5 (ease of use) subjectively evaluate the training outcomes and hence peer review process was employed to establish their appropriateness.

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[34] It needs to be remembered that Questionnaire 5 was applied after the training had been completed and after the subjects undertook tasks ("hands on tasks") in using the Project Management software application for which they had been trained. The first 4 sets of questionnaire items measure the "training environment" itself (eg. use of computers, getting work out of computers including interface usage). The 5th set of items measure the ease of use of the training materials itself. All 5 sets of items were used to reflect the "ease of use" factor impacting the end user training in the given setting.

[35] This is only a peer review on the questionnaires. Pilot study is discussed later under the section 'Pilot Study' in this chapter.

As mentioned in the previous paragraph, the peer review was conducted by two independent researchers[36] who commented on the appropriateness, suitability and applicability of questionnaires to the study. The reviewers questioned the use of certain terms such as 'It was easy to learn the mouse operations' because they felt that question is very open and did not reflect the current context. The reviewers suggested that the questions in Questionnaire 5 be modified into 'I find it easy to learn the mouse operations' to reflect the current context. These comments were taken into account and the training materials were modified to address the concern. Further, certain scales were initially from 'low' to 'high' and these scales were modified to 'Disagree' to 'Agree' to reflect the comments provided by the peer reviewers.

2. Preparation of training materials

Construction of training material in this study consisted of two phases. The first phase examined generic issues such as tasks, their complexity and their level of appropriateness. The second phase consisted of articulating these tasks to instruction or exploration approaches.

Examples of Project Management were developed using the suggestions provided by Campbell (1991), Mayer (1981) and Wood et al. (1990) and were presented in the form of tutorials as suggested by Carrol & Rosson (1995) and Olfman & Mandviwalla (1995). The concepts of the Microsoft Project application were explained in both sets and elaborated as and when necessary. Further, both materials set consists of information on how to recover when things go wrong for both training approaches.

Examples in both the instruction materials and exploration materials consisted of tasks which were made up of sequences of operations. Guidelines given by Wood et al. (1990) and Campbell (1991) were used in preparing tasks for the training materials. Examples on Project Management such as how to create a project schedule were delivered using sequences of training instructions to conduct operations and cues were provided to help learning. For example, users were alerted to the change in the task bar of the Microsoft Project Screen when certain changes were taking place. Further, various screen dumps showing graphical representations of Microsoft Project

[36] These two independent researchers have considerable experience in End User Computing. One has over 20 years of tertiary teaching experience in Computing and the other has over 15 years of teaching experience in teaching end users. Both have published a number of refereed papers in the area of EUC.

for a task were provided to help participants understand the effect of icons or menus and enabled them to learn either or both of the interface types. Both training materials set consisted of commands that could be activated using either interface. Due to the complexity of the commands and their sequences, both the training materials set also provided graphic representations of the actions and responses, where possible.

Further, care was exercised to avoid any ambiguity in the use of terms by consulting staff at Edith Cowan University who had 'education' background and 'Project Management' teaching experience. Irrelevant information was checked by these 'so called experts' for and subsequently removed from the training materials. In both material sets, tasks were broken down into simple sequences of training instructions. The combination of these tasks led to complex tasks. This approach was taken to enable subjects to understand the mechanics of executing tasks and then to build upon their knowledge to carry out complex tasks.

It is important that the preparation of training materials should address any bias that can be introduced in the construction of tasks, task complexity and evaluation. While the instructional design domain provides guidelines on how to prepare tasks, there is no instrument available to measure task complexity. Wood (1986) has suggested that task complexity is one element that influences training outcomes. Mayer (1981) also has studied this in EUC studies and has warned researchers to consider task complexity prior to the commencement of experiments. Dick (1990), Kirkpatrick (1983) and Edmonds et al. (1994) have given guidelines for evaluation of tasks to ascertain their appropriateness to studies. These have been taken into account in this study in the preparation of tasks in the training materials.

Each task included the five characteristics mentioned in the task complexity model developed by (Wood et al., 1990): number, irrelevance, ambiguity, conflict, and change. Number refers to the total amount of information (e.g., cues) given to the subjects in the content component of the task. This (number) was verified for adequacy. In the context of the situation, an increase in number might mean a decrease in the time available to make decisions because subjects' need to process the instruction before taking decisions. In this study, the balance between number and time was verified by testing the training materials within a specified time with basic users (who were not involved in the experiment) during preparation.

Irrelevance is information in the content of the task which is not pertinent to the decision making. Irrelevance also refers to factors in the context of the task which divert attention away from the task at hand. Training materials were checked to ensure that this was avoided. Ambiguity is a lack of clarity, obscurity, unreliable evidence, incomplete information, vagueness or the possibility of assigning multiple interpretations or meanings to data. Training materials were again checked by the 'education experts' to remove ambiguity. Where it was not possible to remove the ambiguity in certain technical terms, additional information was provided as clarification.

Conflict is the mutual interference of opposing forces or information. Training materials were checked to see whether there was any conflict in the information provided. For instance, during the initial versions of the training materials, the screen shots referred to a staff computer where the settings were different and this resulted in a conflict in the information provided and the information available on subjects' computers. By using an identical setting to that of the subjects' computers, the conflict was avoided.

Change is a difference, fluctuation or variation in form, quality or state. Due to the various settings in the computer laboratories, there were minor variations in the way in which students saw the hardware settings. This was resolved by removing any dependencies on the hardware materials (such as printers). Once the training materials were ready[37], they were given to three sets of people for preliminary testing purposes. The first group consisted of 3 Computer Science lecturers who had project management knowledge and they tested the materials for appropriateness, relevance etc. The second consisted of 6 postgraduate students for time and operational sequences. The third set consisted of pilot group, which is discussed later.

Instruction-based material

The training material set developed for this study included two training approaches, instruction based training and exploration based training. Both sets of materials contained examples different from the tasks used in the experiment.

[37] Both sets of training materials were in print and only the print form was given to participants. The print form included screen dumps to highlight the context.

The instruction training material consisted of step-by-step instructions in order to explain the functional elements of Microsoft Project. This material defined and controlled almost all aspects of learning, including specific items to be learned, the sequence of items and the manner in which the instructions were presented. Information was provided for the learner to read and work through step by step, therefore, this material was complete in the sense that learners did not need to look for information outside this material. The focus of this material was on specific features of the application and instructions to assist users to perform simple and complex operations. Learners were not allowed to create their own examples while using this material and were provided with little opportunity to digress from the given material. This material encouraged learners to discover general rules by working through specific examples.

Exploration-based material

The second set of training materials, the exploration materials, provided instructions only for a general framework. The focus of this material was on broad outcomes. This material did not use specific examples and users were allowed to create their own examples to understand the application. This material was left incomplete, i.e. not all aspects of the general framework were given, and learners were encouraged to explore the application in order to comprehend its functions. With these materials learners were encouraged to reason from general rules to specific examples. Therefore, these materials transferred much of the control of learning process to the learner.

While the instruction approach provided information cues to match step-by-step instructions, the exploration approaches provided information cues as and when necessary. Certain information cues were deliberately left out in the exploration materials to facilitate exploration. To assist users in remembering icon and menu actions, screen shots of icon and menu information of the application were also provided.

A sample screen dump[38] used in the training materials and associated instructions are given below to illustrate its purpose. It can be seen from the screen

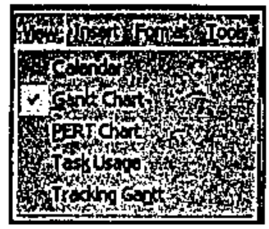
[38] It was mentioned during the training that subjects are allowed to use both types of interfaces and they will be asked to nominate their preference (based on the experience gained) at the end of the training.

dump that the training materials consist of both step-by-step instruction and screen-shots of MS-Project. The purpose was to facilitate both instruction and exploration approach to subjects and then allow them to choose their preferred approach. While it is possible to argue that training materials consist of both types of interfaces and hence there is possibility that subjects would learn both types of interfaces, in this study, subjects were asked to nominate their preferred choice of interfaces and training approaches to suit their learning style. This is referred in some sections as "the preferred .." in the thesis later. The choice of selection of interface and training approach was made prior to the experiment (not during training) and the experiment was controlled at that point. This is done to avoid criticism found in previous studies that subjects were forced to use certain types of interfaces or training approaches and this forced nature could have impacted training outcomes.

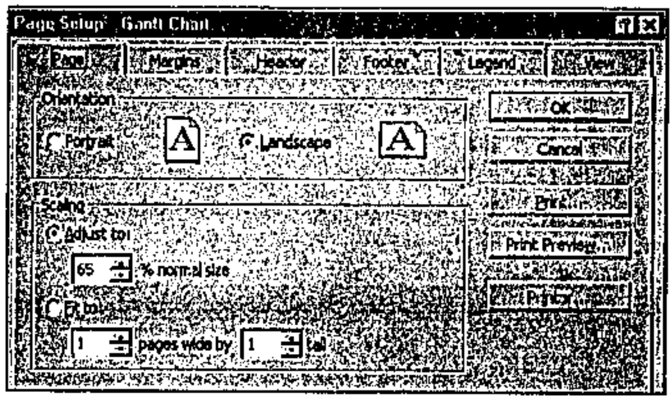
This nominated interface was recorded into the database and was subsequently used in the experiment (hands on tasks).

Viewing GANTT Chart

1. Go to View menu
2. Ensure the Gantt Chart tab is checked
3. Click on Print Preview icon
4. When the schedule is big, the print preview would span more than one page. MS Project provides provisions to contain the GANTT view into one page. To do this:



1. Go to File menu
2. Go to Page Setup option
3. Select the Page tab
4. Ensure Fit to tab is checked with 1 page wide by 1 page tall
5. Click OK
6. Click on Print Preview icon
7. Once viewed, CLOSE Print Preview



Care was exercised in constructing operational sequences that are as similar as possible for both training approaches. In addition, with a training approach, users were provided with sequences of operations that can be performed using both icons and menus. Screen dumps in graphic forms have been provided in order to enhance learning. Following is a list of topics that were covered in both the training materials:

1. What is project Management?

This topic introduced subjects to some basic concepts of project management. The topic covered aspects of project management, the need for it to be used in industries etc.

2. What are the advantages of using project management software?

This topic introduced the concept of project management software and why such a software should be used as opposed to some other applications.

3. What are the project management scheduling techniques?

This topic elaborated on the scheduling techniques used in a project management environment and their importance in that environment.

4. How to enter data in MS Project?

This topic covered specific aspects of Microsoft Project for the purpose of entering data. Aspects of entering data are covered using step-by-step procedures as well as pictures showing how the computer screen will look at various instances of data entry.

5. Opening, saving and closing files

This topic covered aspects of file management in Microsoft Project. Shortcut keys, menu commands and details pertaining to file management are covered in this topic.

6. How to create a new project?

This topic covered points relating to how to create a new project. This involves how to enter schedule events in Microsoft Project, how to enter time and resources, how to govern milestones etc.

7. How to view a GANTT Chart?

This topic provided instructions using Microsoft Project on how to view a GANTT Chart in order to see how the project is developing. Various views of GANTT chart are discussed in this topic.

8. Exercise on creating a simple task schedule

This topic covered simple exercises for the subjects to reinforce the concepts covered in the previous topics.

3. Peer review of training materials

To avoid the criticism encountered in previous studies on the arbitrary nature of training material development, this study employed a rigorous peer review process. Two colleagues at Edith Cowan University reviewed the materials based on the five characteristics of tasks – number, irrelavance, ambiguity, conflict and change. In addition, six students, who were not involved with the experiment, tested the training materials and instruments for accuracy, appropriateness, relevance and readability. For example, the term "link" has a special meaning in project management compared to the term "'linking" in other computing environments. This type of ambiguity was identified and explained during training.

The colleagues who reviewed the training materials made a number of comments. Some of which are given below:

- Many of the worksheets and answer sheets could be improved with some minor formatting changes as shown on the following pages.
- Examples of GANTT charts were needed.
- Screen dumps were needed for certain actions.

These comments were subsequently incorporated into the training materials. The final version of the training materials is included as Appendix 7.

4. Ethical Clearance

According to Edith Cowan University guidelines, students and staff engaged in research work should obtain ethical clearance before commencement of any experiment. In this study, students were used as surrogates and hence 'openness' of the information provided was crucial. Subjects were exactly told what is going to happen in the study and were made aware that the participation is voluntary. The participants were also informed that the information provided for the purpose of the study will be kept confidential and has no bearing on their education. In addition, the survey forms, training materials and other associated materials such as covering letters given to subjects, introductory letters given to subjects (explaining the purpose of research) were all 'quality assured' in order to remove any unintended bias introduced. The procedures were documented and accepted by a committee at Edith Cowan University as acceptable practices.

5. Pilot study

The next step in the process involved conducting a pilot study to assess the suitability of the material for the experiment. In order to facilitate the pilot test, 15 subjects were chosen who were not involved in the experiment. They were drawn from a population with comparable characteristics. The pilot study was organised into three sessions. The first session included a briefing session and completion of the first three questionnaires to ascertain level of knowledge, experience and learning style preferences. The second session was training. The third session involved hands-on tasks (the experiment) and filling in the last two questionnaires.

During the second session of this pilot study, the training session, the following problems were noted:

- Questionnaire 1 and 2 contained typographical errors.
- Questionnaire 3 was difficult to read due to the background colour put on alternate questions.
- The training materials contained of references that were not set as standard options in the laboratories. This created confusion.
- The operating system settings were different from that of the machine with which the training materials were prepared. Therefore, certain steps were not executed as per the instructions in the training materials.
- The application software version was different from that in the laboratories and resulted in certain operations of the training materials not being used.
- Students were not able to remember the steps they executed during training while performing hands-on tasks.

The training materials and survey forms were modified and tested again by the same six students. These students then confirmed that the problems reported earlier had been addressed and eliminated in the refined training materials. The training materials included as Appendix 7 is the final versions. The modified materials were again sent to the ECU Ethical Clearance Committee for approval.

One of the problems that emerged during the pilot study was filling in the responses to the hands-on tasks of the experimental phase such as time taken, correct strokes, etc. The pilot subjects had difficulty in filling in the answer sheet used to record their responses because they were not able to remember their responses afterwards. They recommended that an automated tool be used to record the actions. This resulted in the installation of a software application called the Lotus ScreenCAM.

Due to the decision to install screen cameras to capture activities conducted during the experiment, various models were examined. The two products that met the specifications were Lotus ScreenCam and Microsoft's CamCorder. It was initially decided that Microsoft CamCorder would be installed in the laboratories because this was covered under Microsoft site licenses. However, due to different versions of processors, the CamCorder did not run on all the computers. This then prompted the installation of Lotus ScreenCam which ran successfully on different processors. Lotus agreed to an installation of ScreenCam on the University laboratories for two sessions per software purchase. Lotus also insisted that students should NOT copy the software.

The pilot subjects were then distributed with a response sheet to record their operations by replaying the ScreenCAM or Camcorder files. This required the pilot subjects to fill in number of keystrokes, the number of accesses to menu items, the number of accesses to icons, the number of errors committed, the number of backtracks performed and the overall time taken to complete the exercise. However, when the initial batch of subjects replayed the data recorded, it took over two hours to transpose the responses of 45 minutes work. As the data capture session went beyond the stipulated time of maximum two hours, it was decided that the files will be saved and the data such as keystrokes will be captured externally later.

Experimental procedure

In order to test the research hypotheses, an experiment was designed for a laboratory setting. The following sections explain the experimental procedure.

1. Briefings to subjects

Once the training materials and survey forms were finalised, students were approached to participate in the study. Initially, 65 volunteers were chosen to fill in the first three questionnaires to validate them. The results of the validity of the questionnaires are discussed in the Data Analysis chapter. Other subjects who expressed an interest to participate in the study were allocated to various sessions of the experiment in order to minimise any disruption to their regular tertiary studies. They were asked to assemble at various computing laboratories in order to start the experiment.

2. Questionnaires 1 and 2

About 200 students (stratified samples, including the 65 mentioned above) filled in questionnaires 1 and 2. Students who had experience with project management applications were again reminded not to participate in the study to avoid any bias. The students, under the supervision of their respective lecturers, filled in the first two questionnaires. Students were allocated a token number to ensure anonymity.

3. Screening of Subjects

The first two questionnaires were used to determine the suitability of subjects for this study. The students ranged from 19 years to 55 years of age, belonged to both genders and possessed a variety of skills in applications software.

In addition to subjects who were familiar with Microsoft Project, twelve students who indicated later that they were familiar with the concepts of Project Management were also eliminated from the study. Subjects who had indicated that they knew a lot about questions 6 and 14 (questions on project management) of Questionnaire 1 were also eliminated from participation.

Details of the remaining 183 students were entered into a database with their token number and their family name, given name, the university instructor or lecturer's name for maintenance and follow-up purposes. For confidentiality reasons, details such as course, student identification number and other course details were not recorded into the database.

The grouping of subjects into the two user categories was decided in an arbitrary manner. Any subject who scored an average of 3.5 and over, out of 5, would be considered an advanced user. The average was calculated for the two questionnaires 1 and 2. To be an advanced subject, an average of 3.5 and over in each questionnaire was required.

4. Questionnaire 3

A week later, subjects were given the third questionnaire. Subjects were instructed to answer either with a tick (implying "agreement" to the statement in the questionnaire) or a cross (implying "disagreement"). Subjects were asked not to leave any responses blank.

As expected, this questionnaire required about 30 minutes to complete. Six subjects expressed their inability to participate in the survey at this point of time due to other work or academic commitments bringing the total subjects number down to

176. Once the data was collected, an algorithm[39] given by Honey & Mumford (1992) was used to categorise subjects into their preferred learning style. The following table[40] provides the distribution of subjects in terms of their level of knowledge and learning style preferences.

Table 3.1 Frequency distribution of level and learning style preferences

		Learning style				Total
		Activist	Reflector	Theorist	Pragmatist	
level	Basic	22	21	23	17	83
	Advance	16	27	16	17	76
Total		38	48	39	34	159

Note: The table is extracted from the statistical analysis of data and includes incomplete subjects and outliers. Hence 159 in total column instead of 176 as mentioned.

4. Installation of software applications

As mentioned previously Lotus granted permission for the installation of their software application ScreenCam for two sessions per purchase of a licence. So, it was decided that the ScreenCam would run in conjunction with Microsoft Project, in a Windows 95 environment, under the Novel network. In one campus, it was not possible to use any other laboratories due to heavy bookings. Therefore, it was decided that Microsoft Camcorder, which was comparable, would be used for the purpose of data recording. Because this campus was a regional campus, about 200 km from the main campus, it was agreed to conduct the experiment on a different schedule from that of the metropolitan campuses.

For the installation of software application Microsoft Project, a special disk volume was created to enable collection of data confidentially. Only two staff members had read access to this disk volume. Students were allocated a special

[39] The algorithm was written in Visual Basic and enclosed as Appendix 9.

[40] The table accounts for only 159 students because certain students did not save their files properly and the data for these students were not included in the final data analysis. This is explained in a later section.

password that allowed only write access to this disk volume. This access was to enable students to save their work during the hands-on tasks of the experimental phase. This arrangement facilitated the data collection in a short time.

5. Training

Once the necessary software applications were installed and tested, training was provided. As planned, the training was provided a week later. A training session of 45 minutes was initially allocated. Students were allocated to any of the 10 sessions of training provided. The training commenced on 26 April 1999 and concluded on 2 May 1999. Due to various academic work pressures, a few students did not attend the training.

A total of 176 subjects attended the training and they were briefed about the two training approaches. During training, subjects were asked to work on both sets of training materials. They were allowed a total of 45 minutes per set. This time excluded any housekeeping such as logging into the network. Subjects were allowed to ask questions and they were provided with answers. In addition to this, once the training was completed, subjects were asked to nominate their choice of interface — icon or menu, and training approach – instruction or exploration. Subjects were instructed that once they nominate their preference for interfaces and training approach, they must use only the nominated approach. The subjects were also informed of the procedures of recording their actions to highlight the importance of using only the nominated types of interfaces and training approaches. Subjects were also informed of the marking key used to extract effectiveness factors and that using a wrong interface type may be considered as a wrong action. The nominated preference of interface type and training approach was recorded into their database. Once the training was completed, subjects were asked to return the sets of training materials to the instructor. Subjects were not given access to training resources after their respective training sessions.

At the end of the training session, subjects were categorized based on their level of knowledge and subjects had nominated their interface choice and training approach choice. The following figure (Figure 3.3) provides the distribution of subjects to each group:

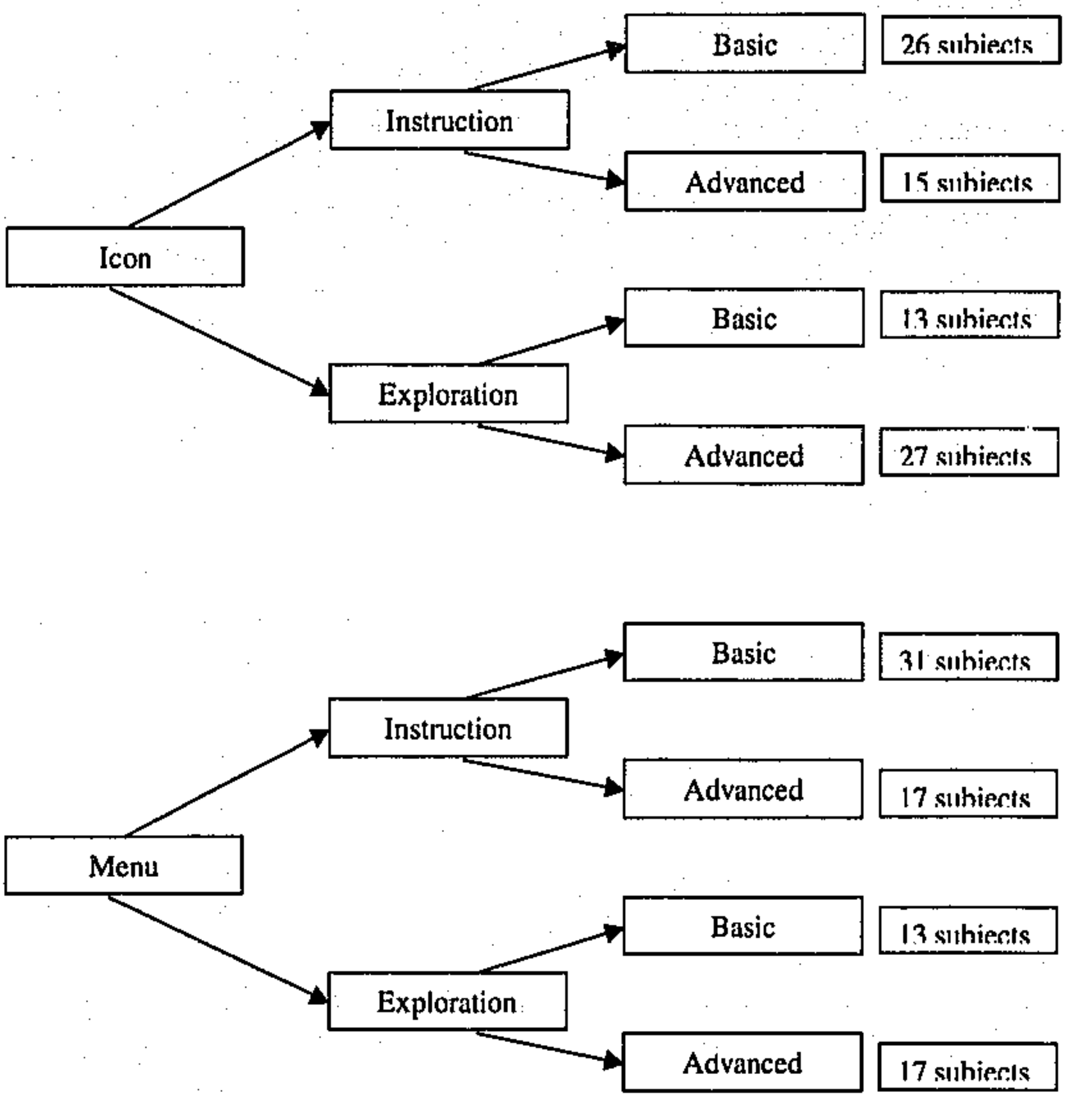


Figure 3.3 Groupings

6. Hands-on tasks testing

Once the training component was completed, Lotus ScreenCam was installed in all the laboratories where training had been provided. Ten subjects participated in the first hands-on task testing. Subjects were given an introduction to the overall operations, how to save the data and where to save the data. They were also told about their password and the disk volume where the data could be stored. They were told how to use the Lotus ScreenCam software and the operations of this application.

This study used a time frame of 45 minutes for the hands-on experiment component because previous studies in EUC training have employed a duration of about 45 minutes for the purpose of training (Blili et al., 1998; Bohlen & Ferrat, 1997; Davis & Bostrom, 1993; Sein & Bostrom, 1989). In addition, this time period also coincided with the laboratory bookings and release to other lecturers at Edith Cowan University. Once the tasks were completed, subjects were asked to store their file at a specified disk volume. As indicated in an earlier section, in order to avoid the time consumed in capturing the data, it was decided that subjects would just save the Lotus ScreenCam version of the data and the replay would be performed at a later point. A total of twelve sessions were planned to accommodate the subjects at metropolitan campuses. A total of 159 subjects completed the hands-on tasks exercises. The data were also backed onto six high volume diskettes in compressed form for data entry and subsequent analysis.

7. Measurement of training outcomes

Outcomes in this study were assessed using three measures – efficiency, effectiveness and ease of use. Subjects involved in the study were provided with hands-on exercises consisting of twelve tasks, where tasks need to be completed in a sequence. Completion of each task involved individual steps. A step is defined as an information entry or an action taken in the application. In this study, Subjects who nominated icon interfaces to accomplish tasks were instructed to use only icons in accomplishing the tasks. Use of menus to accomplish tasks is considered a wrong step.

The first measurement was the effectiveness. This measure was dependent upon score. As participants completed each step in the given task, it was recorded using the Lotus screen camera. While completing a given task, a participant would enter data in a cell, or interact with an icon, menu item or backtrack to a previous step or commit an error. Therefore, the measure effectiveness was calculated in terms of every action performed by participants.

To obtain meaningful measures, a unit score of one was allocated to each key action in conducting a task. A key action included entering data in a cell. Other actions included an icon activation, menu access or interaction with a dialogue box. Unit weights were allocated to cell data entry, as the information-processing load is crucial at this step. Users need to understand what needs to be entered, how to enter the data, what formats needed to be chosen and so on. This study allocated half the unit scores to every step performed using icons or menus or dialogue boxes as these interfaces convey the same meaning for the users and the information load is straightforward. Errors and backtracks were allocated a negative unit weight in order to determine the accuracy of steps involved in completing a given task. The outcome effectiveness was computed from a combination of these actions. In this study subjects were already exposed to a different software environment such as Microsoft Word and Excel and hence the information processing abilities were treated equal for every activity undertaken by the users.

Based on these allocations, it was possible to define the factors effectiveness. Effectiveness was defined in terms of the "score" gained by the number of steps used to conduct a task; number of errors committed and the number of backtracks performed in completing a step. To be effective, users would use steps with precision. In other words, to be effective, users would use the correct keystrokes in the correct sequence in order to arrive at completion of a task. The effectiveness was verbalised as:

Effectiveness = function (total strokes, icon access, menu access, dialogue box interaction, errors, backtracks)

This is shown mathematically shown as

$$\textbf{\textit{Effectiveness}} = \boldsymbol{f(TS, IA, MA, BTRK, ERR)}$$

This effectiveness formula resulted in the correct strokes, where correct strokes = TS + 0.5 IA + 0.5 MA – BTRK – ERR.

For efficiency, time is measured. In this study, to measure time a computer clock was used. Participants were asked to store their work in a specific location on a computer network and the time of completion is recorded from the file details. The starting time was recorded manually. For calculation purposes, the raw time in minutes was converted to a unit, where an hour was interpreted as 100 portions. Efficiency was measured in "time" and was defined as:

Efficiency = function (time, correct strokes)

Efficiency = time / Correct Strokes

This is shown mathematically as

Efficiency = f(T, CS)

Efficiency = T / CS

The third outcome ease of use was measured using an opinion survey. The survey instrument consisted of 28 questions over 5 sections. Subjects answered to these questions by denoting their opinion on a 5-point Likert scale where the scale ranged from 1 (disagree) to 5 (agree).

8. Questionnaire 4 & 5

Due to time constraints, this study was not able to measure satisfaction and ease of use immediately after the experiment. There was a one week delay in measuring these two aspects. During the week beginning 24 May 1999, subjects who had completed the hands-on testing (experiment) were asked to complete the next two questionnaires. The fourth questionnaire extracted levels of satisfaction and the fifth questionnaire extracted the perceived ease of use. As expected, the time taken was about 30 minutes for both the questionnaires.

9. Data entry

It was essential to enter the data into a software application in order for analysis. Microsoft Excel, Version 97 was chosen for this purpose. The choice was determined by the availability of this application at various departments and research centers at Edith Cowan University. Further, it was possible to write some programming codes using Visual Basic in Excel to extract subjects' level of knowledge.

To maintain accuracy, it was also decided to conduct a double data entry procedure and then compare files. This procedure would help to identify anomalies and then correction of data. However, for the purpose of data entry, a coding scheme needed to be devised. This study used a numeric code 1 for basic level users and 2 for advanced level users. Similarly, a numeric code 1 was used for instruction training approach and 2 for exploration training approach. For learning style preferences, this study used numeric code 1 for users categorised as activist, 2 for users categorised as reflectors, 3 for users categorised as theorists and 4 for users categorised as pragmatists.

Questionnaire 3, the learning style preference questionnaire, was entered and, by comparing the files all the type errors were eliminated. Then, a Visual Basic program was used to extract the preferred learning style of subjects. This program was based on the guidelines given by Honey & Mumford (1992). The Visual Basic code is included as Appendix 9. Data were then checked for any potential mistakes. The Visual Basic code was checked and the computation was also checked for any potential errors.

Conclusion

This chapter has provided information on how the instruments were chosen, how these instruments were peer reviewed for ambiguity and how the training materials were developed. Previous studies have been criticised for their 'subjective' nature in instrument developmental procedures and this study has exercised care to avoid any 'subjective' bias introduced by performing peer reviews at various points. All instruments used in this study, training materials and other documents were reviewed by experts and peers in order to avoid any compounding effects that could be introduced by ignorance. Further, while a majority of previous studies used a manual process to track keystrokes and other time component involved in the determination of training outcomes, this study has used an automated procedure to track all the steps performed by the subjects. The advantage of using an automated procedure is accuracy. In addition, the tool used in this study, namely Lotus ScreenCAM, captured all sequences of action and hence it was possible to review the files at a later point of time for any clarification. This also has helped to accurately determine the number of keystrokes, errors committed, backtracks and time components.

Further, the overall experiment was divided into a number of components and these components were of manageable sizes. Executing these components in a predefined sequence ensured that the experiment was conducted as per schedule. In addition, the peer-review and pilot-study helped to alleviate a number of problems prior to the experiment and these two procedures helped to refine the overall quality of the experiment. In summary, the collective procedures – peer review of instruments, pilot study, inclusion of automated tools to capture data – have guaranteed that the experiment was executed as planned.

The next chapter presents data analyses, which include the verification of data, preliminary data analysis and hypothesis testing. The various statistical techniques used to verify the data and test the hypotheses are provided in the next chapter.

CHAPTER 4 – DATA ANALYSIS

In this chapter, the data analysis procedures are discussed in terms of data entry procedures, descriptive measures and multivariate analysis. The data entry procedures highlight the steps taken to ensure the manual data was accurately transformed into computer files. Once this was completed, procedures were followed to ensure the validity and reliability of the questionnaires used in this study. The descriptive measures highlight how the data were checked for integrity to facilitate hypotheses testing. Then multivariate analysis was carried out in order to ascertain acceptance or rejection of the hypotheses. The chapter concludes with a summary of findings from the statistical analyses performed.

Data entry procedures

In order for the data to be analysed, the manual data captured from the five questionnaires needed to be transformed into computer files. This conversion involved the data filled-in by subjects in the five questionnaires, namely, prior knowledge (Questionnaire 1), prior experience (Questionnaire 2), learning style preference (Questionnaire 3), satisfaction (Questionnaire 4) and ease of use (Questionnaire 5). In addition to this, the Lotus ScreenCAM files were also played back to record details such as number of keystrokes used, number of times icons accessed, number of times menus were accessed and number of times errors were committed. These were also for transformed into computer files. The following paragraphs detail these procedures.

When raw data are converted from existing paper formats into computer data files, accuracy needs to be guaranteed to avoid any typographical errors. Gilbert (1989) states that one such inaccuracy may be any subjective bias introduced by the researcher and this inaccuracy needs to be eliminated during data collection and entry procedures. Bowman et al. (1994) proposes that a double entry[41] procedure is an

[41] Double Entry refers to entering data by two independent people. Usually an electronic form is created for the purpose and two different people enter the same data on two computer files based on the form.

efficient way of converting manual data into an electronic form in order to avoid any typographical errors. The data processing industry also follows this approach. Therefore, it was decided that two research assistants would be used for the double entry procedure to eliminate any bias or typographical errors.

The manual responses to the questionnaires were recorded in an Excel spreadsheet by the two research assistants. A file comparator method[42] was used to identify any discrepancies and these were resolved by referring back to the original source. In the case of ScreenCAM files, details of user actions needed to be summarised on paper prior to conversion to computer files because it was difficult to perform data entry while simultaneously replaying ScreenCAM files. To enable data entry, the research assistants captured the following details while playing the ScreenCAM files:

- number of times icons were accessed;
- number of times menu items were accessed;
- number of times steps backtracked or revisited;
- number of times errors were made;
- the start time of the hands-on task (noted from the system clock); and
- the end time when the application was closed (noted using the time recorded by the system at the Windows folder level).

For instance, the research assistants recorded on paper the number of keystrokes performed by a user while replaying the ScreenCAM file in the paper form provided. Once this was accomplished, the research assistants provided a summary of all actions on paper. The summary responses were checked and exceptional cases identified and rectified by playing back the ScreenCAM files again.

The double data entry procedure was used again to convert the ScreenCAM summary of actions to an Excel computer file form. The files were again compared using the file comparator technique. The research assistants eliminated errors by referring to the paper form. This completed the data entry procedures.

[42] This method compares two computer files created from the same source data and provides details of anomalies.

Questionnaire reliability and validity tests

Zikmund (1994) states that reliability and validity are two important criteria to ensure that the instrument used such as a questionnaire is appropriate for a specific study. The reliability is a necessary condition for validity. In this study instruments were statistically tested for reliability and validity prior to data analysis to ensure that they were appropriate in addition to the peer-review and pilot-testing carried out before data collection, as discussed in the previous chapter.

<u>Reliability</u>

The reliability of an instrument is defined as the degree to which its measures are free from error and therefore yield consistent results (Zikmund, 1994). When instruments are tested for reliability, two aspects – repeatability and internal consistency are tested (Simon et al., 1996). Performing a test-retest method using a statistical application ensures repeatability. Internal consistency is ensured using procedures such as the split-half method (Lee et al., 1995). This study follows the approach[43] used by Simon et al. (1996) to ensure the reliability of the instruments used. The actual results arising from reliability tests are reported in the next section.

<u>Validity</u>

Validity addresses the problem of whether a measure (for example, an attitude measure) measures what it is supposed to measure (Zikmund, 1994). According to Zikmund, the validity of an instrument, in this case a questionnaire is, usually assessed using three basic approaches. They are:

1. content validity;
2. criterion validity; and
3. construct validity.

Content validity refers to the subjective agreement that a scale logically appears to accurately reflect what it purports to measure (Zikmund, 1994). *Criterion validity* is an attempt to find out the correlation of one measure with other measures in a construct (Zikmund, 1994). *Construct validity* is the ability of a measure to confirm

[43] Simon et al (1996) conducted a number of tests to ensure that data were ready for statistical analysis. Ruble and Stout have criticised EUC studies for not following such reliability tests prior to data analysis. Hence, the decision was made to to follow Simon's approach.

a network of related hypotheses generated from a theory based on the concepts (Zikmund, 1994). The following section reports the outcome of reliability and validity tests.

Reliability tests

This study used five questionnaires. They tested for prior knowledge (Questionnaire 1), prior experience (Questionnaire 2), learning style preference (Questionnaire 3), satisfaction (Questionnaire 4) and ease of use (Questionnaire 5). Of these five questionnaires, the first questionnaire was based on the guidelines given by Bohlen & Ferrat (1997) and modified to suit this study. This questionnaire was tested for internal consistency using split-half method. The second and third questionnaires were adopted from Simon et al. (1996) and Honey & Mumford (1992) respectively and used without any changes. These two questionnaires had already been tested for reliability in those studies. Questionnaire 4 – Satisfaction was adopted from Igbaria (1990) and minor modifications were incorporated to existing questions to suit this study. Therefore, only standard reliability tests such as split-half method were performed on this questionnaire.

The last questionnaire, Questionnaire 5 – *Ease of use* (adopted from (Davies et al., 1989)) – was specifically modified to suit this study. With regard to Questionnaire 5, the original instrument consisted of only 4 questions and did not include questions on aspects such as training environment. This questionnaire was modified extensively to include 28 questions over 5 sections and hence this questionnaire was considered new. Igbaria (1990) states that it is a customary practice to assess modified questionnaires in each new study to find out how reliable the constructs are in order to arrive at an accurate measure. With this in mind, the reliability of questionnaire 5 used in this study was tested. Further, this questionnaire was used in determining one of three training outcomes and hence was tested for test-repeatability to ensure that a reliable instrument was used to determine the 'ease of use' training outcome.

Questionnaire 5 was tested first on the pilot group. The questionnaire items were averaged and the average satisfaction for the pilot group was 3.31 out of 5 when the questionnaire was tested soon after their training. When questionnaire 5 (ease of use) was again tested on the same pilot group for repeatability after the hands-on tasks (experiment), the average ease of use for the entire population was found to be 3.43. Zikmund (1994) states that this level is an acceptable level for verifying repeatability for a questionnaire that has undergone extensive modification. Therefore, the repeatability was assured with this instrument. When the questionnaire was tested on the study population, a score of 3.51 was obtained indicating repeatability.

The internal consistency was tested (after hands-on tasks) using the split-half method. Questionnaires 1, 4 and 5 were tested for this aspect. For questionnaire 1 –a value of 0.8792 was obtained using the Spearman-Brown method. Using the Guttman Split-half method, a value of 0.8736 was obtained. For questionnaire 4 –a value of 0.9127 was obtained using the Spearman-Brown method. Using the Guttman Split-half method, a value of 0.9124 was obtained. For questionnaire 5 – using the Spearman-Brown method, a value of 0.8823 was obtained. Using the Guttman Split-half method, a value of 0.8793 was obtained. Simon et al. (1996) state that a high value (i.e. values over 0.8) is proof that the instruments are consistent. In this study, questionnaires 1, 4 and 5 attained a value of over 0.8. Therefore, it can be argued (after (Simon et al., 1996)) that Questionnaires 1, 4 and 5 were reliable in terms of internal consistency.

In addition to the above tests, a number of generic tests were conducted. The parallel estimated reliability of scale test returned a value of 0.9259 for questionnaire 1, 0.9369 for questionnaire 4 and 0.9632 for questionnaire 5 respectively. The unbiased estimate of reliability returned a value of 0.9267 for questionnaire 1, 0.9376 for questionnaire 4 and 0.9637 for questionnaire 5. When a strict estimated reliability of scale test was performed, a value of 0.8649 for questionnaire 1, 0.9351 for questionnaire 4 and 0.9562 for questionnaire 5 was returned. When a strict unbiased estimate of reliability was used, it returned a value of 0.8672 for questionnaire 1, 0.9362 for questionnaire 4 and 0.9570 for questionnaire 5. As the values returned by these tests were over 0.8, it can be assumed that this was an indication of the reliability of the instruments used in this study (Zikmund, 1994). This is presented in the following table (Table 4.1).

In addition, questionnaire 5 was tested individually on the five sections of the questionnaire. This reliability test was conducted to find the extent to which the items used to assess a construct reflect a true common score for the construct. The internal consistency reliability for the 28-items was calculated in two different ways. First, correlation between each item under the five categories – learning to use computers, becoming skilful at using computers, getting work out of computers, operating the computers and using the training materials – were calculated. Second, the alpha values were calculated.

Table 4.1 Reliability Test Results

Test Questionnaire	Reliability Test	Type/Value
Questionnaire 1	Gutmann Split-Half	0.8736
Questionnaire 4	Spearman-Brown	0.9127
Questionnaire 5	Gutman Split-Half	0.8793
Questionnaire 1	Parallel Estimate	0.9259
Questionnaire 4	Parallel Estimate	0.9369
Questionnaire 5	Parallel Estimate	0.9632
Questionnaire 1	Strict Estimate	0.8649
Questionnaire 4	Strict Estimate	0.9351
Questionnaire 5	Strict Estimate	0.9562
Questionnaire 1	Strict Unbiased Estimate	0.8672
Questionnaire 4	Strict Unbiased Estimate	0.9362
Questionnaire 5	Strict Unbiased Estimate	0.9570

The first test – correlation – was performed to ascertain homogeneity. The second test – Cronbach alpha – was performed to ascertain inter-item reliability. The questionnaire was found to be correlating with values over 0.70 for all items indicating that questionnaire items were strongly correlated. Further, the Cronbach's alpha method of reliability produced a value of 0.9109 indicating the reliability of items in the five categories. The correlations and the alpha value provided evidence that questionnaire 5 was reliable. This indicated that the instrument used was free from error and would yield consistent results.

Content Validity

Content validity, also known as face validity, is evident in an instrument such as a questionnaire, when it appears that the measure provides adequate coverage of the concept (Simon et al., 1996). The content validity of all the five questionnaires used in this study refers to the representativeness and comprehensiveness of the items used. Several existing (and valid) measures of user participation and satisfaction were used in this study. In addition, all the questionnaires were peer reviewed for suitability of content. Further, three questionnaires (questionnaire 2, 3 and 4) were adopted from previous studies without much modification and the other two were modified to suit this study. In addition, all the questionnaires were tested and approved in terms of their content and appropriateness by peers and independent subjects, who were not subjects in this study. Hence it can be argued that the content validity of instruments was retained in this study.

In generating the additional items for Questionnaire 5 (Ease of use), this study considered 28 questions. The original questionnaire which consisted of only 4 questions, was expanded to include these 28 questions over five sections: (i) learning to use computers (5 questions), (ii) becoming skilful in using computers (5 questions), (iii) getting work out of computers (5 questions), (iv) operating computers (5 questions) and (v) using training materials (8 questions). The expansion included new questions to extract information on the overall training environment in addition to specific issues of project management. The questions aimed to capture the perceived ease of use of the operating system, the project management software application and the training material. Users responded to the statements using a Likert type scale ranging from 1 (disagree) to 5 (agree). This has ensured that a comprehensive conceptualisation was employed as suggested by Bohlen & Ferrat (1997), which included direct and indirect forms of participation, and formal and informal activities. For instance, questions such as "The computer system was easy to use" evaluated users' responses on direct participation and questions such as "The training materials demonstrated techniques for the trainees to follow in an easy manner" to evaluate users' responses in an indirect form of participation. This was done to ensure completeness of the questionnaire as recommended by Blili et al. (1998). Together, these procedures enabled a representative and comprehensive sampling of user knowledge and experience, their learning style preferences, their satisfaction with the environment, and the ease of use of operating under given settings, as well as providing evidence of content validity.

Criterion Validity

Criterion validity is the ability of some measure to correlate with other measures of the same construct. Establishing criterion validity for questionnaire 5 (ease of use) would provide necessary assurance that the new measures were valid. This study employed predictive validity using correlations on questionnaire 5 – ease of use.

It can be seen from Table 4.1 that using Pearson's correlation tests, the first four categories of Questionnaire 5 – learning to use computers, becoming skilful in using computers, getting work out of computers and operating computers have strong correlations. The last category of Questionnaire 5 – using training materials – was positively correlated with other groups. Other correlation tests were performed to ensure that the correlations were positive and strong.

To confirm that the correlation was significant between test elements, a test for significance was also performed. A significance level of under 0.01 was obtained for all elements in the questionnaire. This established the fact that the correlation was positive and strong. This is evidence for the claim that criterion validity is retained in the questionnaire.

An additional test was performed with the 'training material' section in Questionnaire 5 as a controlling element to verify that there was no adverse effect on other elements of this questionnaire – ease of use. A partial correlation coefficient was computed using SPSS for this purpose. The results of this test established that the elements correlated strongly. The significance level of under 0.01 was obtained for all elements.

Table 4.2 Correlation Coefficients - Control for training material variable

PARTIAL CORRELATION COEFFICIENCTS					
Controlling for Training Material					
		Learning to use computers	Becoming skillful in using computers	Getting work out of computers	Operating computers
Learning to use computers		1.00			
Becoming skillful in using computers		0.81	1.00		
Getting work out of computers		0.70	0.81	1.00	
Operating computers		0.74	0.85	0.88	1.00

Construct Validity

Construct validity looks at the level to which a scale measures a theoretical variable of interest (Cronbach, 1977). When considering construct validity, convergent validity and discriminant validity are established. According to Zikmund (1994) in applied research, such as this study, it may be possible to ignore discriminant validity because the questionnaires are instruments from previous studies and hence their validity has been previously established. Convergent validity is the ability of some measures in a construct to correlate with other measures.

In this study, the ease of use sub-scales might be considered as five different measures of users' perceptions. Thus, the correlation among the sub-scales can be considered evidence of convergent validity. In this study, the five sub scales – learning to use computers, becoming skilful at using computers, getting work out of computers, operating the computers and using the training materials – were measured. The SPSS statistical analysis using reliability tests (using correlations) showed that correlations ranged between 0.734 and 0.852 (with a p-value < 0.01), which shows that the instruments were complying with convergent validity. Simon et al. (1996) used a similar approach and stated that such correlations and significance levels provide evidence for convergent validity.

Reliability Estimates

Once the reliability and validity of questionnaires was assured, reliability estimates were performed on the factors used to measure training outcomes. The reliability analysis was performed on correct strokes, icon access, menu access, dialogue box interaction, and backtracking, because these factors are used to determine effectiveness. It was found that these items correlated significantly ($p < 0.01$) with each other, and the alpha value was 0.72. Simon et al. (1996) states that such an alpha value is within an acceptable range. This shows that the factors considered are relevant for the determination of training outcomes.

Descriptive Data Analysis

It is customary practice to consider the descriptive analysis of data to determine its suitability for analysis of variance. Descriptive analysis is performed on raw data to enhance understanding and interpretation. The process of descriptive analysis typically involves the calculation of averages, frequency distributions and percentage distributions in summary form. It is generally recommended that this is the first form of data analysis (Zikmund, 1994).

Distribution of responses

The descriptive analysis was performed by initially describing the responses in tabulated form. In this study, there are three major variables – Interface, Training approaches and Categories of users. An additional variable, Learning style, was also introduced to predict effect of the training outcomes. These four variables are referred to as independent variables. The three outcomes, efficiency, effectiveness and the ease of use are dependent upon these four independent variables and are referred to as the dependent variables in this study.

To perform the descriptive analysis, the Excel data spreadsheet was converted to an SPSS file. A frequency distribution was conducted on the three outcome measures or dependent variables – efficiency, effectiveness and ease of use. When this was done, six responses were found to be beyond the normal distribution range of the samples. Many studies choose to ignore such responses, usually called 'outliers', during the analysis of data because they may distort the analysis (Zikmund, 1994). Similarly, these responses were eliminated from the data set in this study.

In statistics, it is common to perform fundamental checks to ensure the data are normally distributed prior to descriptive analysis. In this study, the data were checked for normality. A normal plot was produced for this purpose and the normal curve indicated normal distribution of the data. The plot is enclosed as Appendix 8.

Then the Empirical Rule was applied to ensure that the data was fitted with a bell-shaped curve[44], which is an indication that the data is normally distributed

[44] Usually referred to as Normal Curve.

(Zikmund, 1994). According to Aczel (1993) the Empirical Rule stipulates that for a symmetrical, bell-shaped frequency distribution, approximately 68% of the observations will lie within plus or minus one standard deviation of the mean; about 95% of the observations lie within plus or minus two standard deviations of the mean; and practically all (99.7%) will lie within plus or minus three standard deviations of the mean. For instance, from the table below (Table 4.2), it can be seen that for the training outcome efficiency, the mean was 38.71 and the standard deviation was 13.86. Using the Empirical Rule, it can be seen that 38 + 3 * 13 = 77 (approximately). The maximum value of the observation was 76.80, which is close to 77. Therefore, 99% of the observations are covered within three standard deviations from the mean. This indicates normality of the data. Using this rule, it can be seen from the distribution (provided in table 4.2) that for the three outcomes variables, almost 99.9% of the observations lie within plus or minus three standard deviation of the mean. Therefore, normality was assured.

In addition to this, the data was tested for Skewness and Kurtosis in order to find any aberrations. The Skewness and Kurtosis lay between acceptable limits (-1.00 to +1.00) indicating the normality of the data (see table 4.2, under Skewness Statistics and Kurtosis Statistics).

Table 4.3 Descriptive Statistics (Kurtosis and Skewness)

Descriptive Statistics								
	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
efficiency	11.7818	76.8000	38.7123	13.8667	0.5339	0.1925	0.0099	0.3826
effectiveness	11.0000	93.0000	45.9371	16.9286	0.5134	0.1925	0.1303	0.3826
ease of use	1.3050	5.0000	3.5488	0.7186	-0.3616	0.1925	-0.0180	0.3826

In this study, the data were derived from 5 questionnaires, hands-on tasks scoring scheme and the computer clock. The first questionnaire measured users' knowledge on a 5-point Likert scale and the data were averaged to determine the knowledge level. The second questionnaire consisted of multiple scales such as percentage of reporting, daily usage hours, frequency etc. The questionnaire items were statistically validated using correlations and found to be reliable. Then, the questionnaire items were provided with numerical values ranging from 0 to 5, and these values were averaged to determine experience level. Questionnaire 3 was validated for reliability and an algorithm provided by Honey & Mumford (1992) was used to determine the learning style. Questionnaire 4 and 5 were validated for reliability using correlations and then the questionnaire items were averaged for data analysis.

Efficiency

Efficiency was measured in "time" and was defined as *Efficiency = function (Time, Correct strokes).* Thus efficiency was represented mathematically in the previous chapter as *Efficiency = Time / Correct Strokes.* In this study, the minimum time taken to complete tasks indicates efficiency. With this in mind, the dependent variable efficiency was studied in relation to the independent variables interface, training approach, categories of users and learning styles.

It was mentioned in the previous chapter that subjects were given a hands-on experiment comprising of 12 interrelated tasks. These tasks were done using menus or icons. In this study, subjects expressed their preference for the choice of interfaces – icon or menu – based on the training given. It has already been mentioned that the time was calculated from the computer clock and there was no manual intervention in calculating the time. Similarly, the number of correct strokes was extracted from the ScreenCAM files by the research assistants and this was explained in the previous chapter. Subjects who preferred the icon interface scored a mean time of 37.10 minutes[45] to accomplish the set of 12 given tasks compared to 40.38 minutes scored by subjects who preferred menu interfaces. Similarly, subjects were asked to nominate their preferred training approach. Subjects who preferred the instruction training approach scored a mean time of 38.36 minutes compared with those who preferred the exploration training approach with a mean time of 39.15 minutes. User category – basic or advanced – was determined (not a preference as was the case in interface or training approach) based on subjects' responses to two questionnaires. The basic subjects scored a mean time of 36.75 minutes to complete the given tasks compared to the advanced users who scored a mean time of 40.84 minutes. Similarly, the learning style preference was determined based on the responses provided by subjects in the Learning Style Preference questionnaire. Subjects who were classified as theorists scored a mean time of 36.46 minutes compared with subjects who were classified as activists with a mean time of 38.97, reflectors with a mean time of 40.82 minutes and pragmatists with a mean time of 38.01 minutes.

Mason & Lind (1996) state that "The mean is a very useful measure of comparing two or more population (p.78)". Therefore, the mean value can be used to compare the performance of subjects who preferred one interface type with subjects of another interface type. For example, it can be seen from the mean values that subjects who preferred icon interfaces have performed better in terms of efficiency compared with subjects who preferred menu interfaces in terms of interfaces because they took less time to complete the given set of tasks. Similarly, subjects who preferred the instruction training approach have performed better compared with subjects who preferred exploration approach in terms of efficiency for the variable training approaches. Subjects who were classified as basic subjects were more efficient compared with users who were classified as advanced users in terms of category of user and subjects who were determined as the theorist learning style was more efficient compared with users classified into other learning styles in terms of learning style preferences.

The data were further studied for the combined effort of interface and training on efficiency. The icon interface and exploration combinations scored a mean time of

[45] The time measurement was the average calculated for the group.

36.94 minutes to complete the set of 12 given tasks compared with the icon and instruction combination (mean: 37.25 minutes), menu and instruction (mean: 39.30 minutes) and menu and exploration (mean: 42.10 minutes). The data were also studied for the combined effort of interface and level of users. It was found that the icon interface and basic user combination yielded a mean time of 34.99 minutes to complete the given set of tasks compared with icon and advanced users (mean: 39.06 minutes), menu and basic users (mean: 38.32 minutes) and menu and advanced users (mean: 43.05 minutes). Similarly the combination of preference to training approach and level of users was studied. This analysis provided a mean time of 35.56 minutes to complete the given set of tasks for the instruction and basic user combination compared with instruction and advanced users (mean: 43.33 minutes), exploration and basic uses (mean: 39.36 minutes) and exploration and advanced users (mean: 39.03 minutes).

Therefore, it can be seen from the descriptive analysis (using mean values) that in terms of interfaces, subjects who preferred icon interfaces performed more efficiently. Similarly, in terms of training approaches, the subjects who preferred instruction approach performed more efficiently. In terms of categories of users, basic users performed more efficiently and in terms of learning style preferences, users deemed to be theorists performed more efficiently. Further the combination of icon interfaces and choice of exploration training approach combination performed more efficiently than other combinations. Similarly, icon interfaces and basic users performed more efficiently in terms of the interface and level of user combination. For the preference of training approach and categories of users combination, the data support the choice of instruction approach and basic users performing more efficiently because they took less time to complete the set of experimental tasks.

The following table summarises the independent variables for the outcome efficiency

Tab'; 4.4 Summary for Efficiency on training outcomes

Dependent Variable Combination	Variable	Mean (time in minutes)	Deviation (time in minutes)
Interface	Icon	37.10	13.72
Training Approach	Instruction	38.36	14.31
Category of users	Basic	36.75	11.27
Learning style preference	Theorist	36.46	14.66
Interface x Training approach	Icon x Exploration	36.94	12.40
Interface x level of user	Icon x Basic	34.99	10.17
Training approach x Category of users	Instruction x Basic	35.56	11.26

It can be inferred from the above table that icon interface appears to have a major influence on efficiency outcome based on mean value. This can be seen whereby subjects who preferred icon interface are a recurring component in efficiency results. Similarly, the theorist learning style also appears to have promoted the greatest efficiency. To determine the significance of these, still analysis of variance needs to be conducted.

Effectiveness

Effectiveness was defined as a function of correct strokes, icon access, menu access, dialogue box interaction, errors and backtracks. This was shown in the previous chapter as *Effectiveness = f(CS, IA, MA, BTRK, ERR).* Thus, effectiveness was calculated in terms of number of keystrokes resulting in scores and a higher mean score indicates greater effectiveness. When the dependent variable effectiveness was studied in terms of interfaces, the performance of subjects who preferred icon interfaces were found to be effective with a mean value of 53.86 to complete the given set of tasks compared to the subjects who preferred menu interfaces with a mean value of 37.70. Similarly, for the variable choice of training approach, subjects who preferred exploration approach performed more effectively with a mean value of 48.31 compared with the subjects who preferred instruction approach with a mean value of 44.06. Subjects who were categorised as advanced users performed more effectively with a mean value of 47.27 compared with the basic users, who scored a mean value of 44.71. Similarly, with regard to training styles, subjects who were classified as activists scored a maximum score of 47.86 indicating greater effectiveness compared with reflectors (mean: 47.64), theorists (mean: 45.33) and pragmatists (mean: 42.05).

When the interface and training approach combination was studied, it was found from the mean values that the icon and exploration combination performed effectively with a mean value of 53.95 to complete the given hands-on tasks compared with the icon and instruction combination (mean: 53.78), menu and instruction (mean: 35.77) and menu and exploration (mean: 40.80). The data was analysed further for the interface and category of user combination. This analysis revealed that subjects who preferred icon interface and categorised as basic users were more effective with a mean value of 55.12 compared with subjects who preferred icon interfaces and who were categorised as advanced users (mean: 52.69), menus and basic users (mean: 35.47) and menus and advanced users (mean: 40.58). The data appear to indicate that subjects who preferred icon interfaces were a dominant factor in determining the training outcome effectiveness. When the choice of training approach and level of user combination was studied, the exploration approach and basic user combination was more effective with a mean value of 51.96, followed by the instruction approach and advanced level user combination (mean: 48.81), the exploration approach and advanced level user combination (mean: 46.15) and the instruction approach and basic level user combination (mean: 41.40).

The following table summarises the mean and deviation of independent variables in order to interpret emerging determinants of training outcomes in terms of effectiveness.

Table 4.5 Summary for Effectiveness on training outcomes

Dependent Variable Combination	Variable	Mean	Deviation
Interface	Icon	53.86	17.88
Training Approach	Exploration	48.31	15.70
Level of user	Advance	47.27	16.08
Learning style preference	Activist	47.86	16.26
Interface x Training approach	Icon x Exploration	53.95	16.79
Interface x level of user	Icon x Basic	55.12	17.26
Training approach x level of user	Exploration x Basic	51.96	17.46

It can be inferred from the above table that the icon interface appears to be a major influence of training outcomes in terms of effectiveness because of its occurrence in various combinations. Similarly, the exploration training approach also appears to be a good predictor of effectiveness.

Ease of use

The dependent variable ease of use was used to determine the perceived ease of the overall training environment. The ease of use was determined by a questionnaire that consisted of 28 questions grouped under 5 categories[46]. Users rated the ease of the overall training environment on a 5-point Likert scale (1-Disagree to 5-Agree).

Out of the five categories, the last category – Using the training materials – was used to ascertain the level of difficulty of the training materials. This is because subjects used this training materials to understand the software application and associated operating systems commands in which the application was implemented. Therefore, this category was used to determine the overall ease of the training environment at the time of validating the questionnaire. This has been discussed earlier.

[46] The Questionnaire and its validity to this study has been discussed in Chapter 3, research Methodology, under section "Preparation of Questionnaires".

The other four categories of the ease of questionnaire have direct impact on interface types, training approaches and prior knowledge and experience. For example, the first category 'learning to use computers' asks subjects to rate the operating system commands, meaning of the interfaces etc. This section tested whether users found the underlying hardware environment easy to use. Questions in this section included short cut keys, application software commands, and meaning of computer interfaces. The second set of questions rated the ease of becoming skilful at using computers as a result of the training provided. The questions tested subjects' opinion in using the application software, operating systems and keyboard as a result of training provided. Similarly the other two sections tested the subjects' opinion in executing various commands as a direct result of the training and performing these operations easily. Users recorded their opinion using 'Disagree' or 'Agree' type of scale. These individual categories were used to validate the questionnaire items and this was explained earlier in this Chapter.

The purpose of the questionnaire in this study was to ascertain the overall ease of using the operating environment arising out of training. Hence, the questionnaire items were added and averaged. This has been a common practice in EUC training studies as a number of studies have followed this practice (Bohlen & Ferrat, 1997; Davis & Bostrom, 1993; Olfman & Mandviwalla, 1995; Sein et al., 1993; Simon et al., 1996).

Further, Davis (1985) has used similar questionnaire items in his study to measure ease of using a system and Bostrom et al. (1990), Davis & Bostrom (1993) and Bohlen & Ferrat (1997) have followed similar approaches. The appropriateness of the question items in the ease of use questionnaire has been validated using peer-reviews, pilot groups and other correlation techniques as mentioned in the initial sections of the chapter.

While performing descriptive analysis, it was found that users who preferred menu interfaces rated menus to be easy to use in the given training environment with a mean value of 3.71 on the 5 point scale compared with the users who preferred icon interfaces with mean value of 3.39. Similarly, for the independent variable training approaches, users who preferred the exploration training approach rated this approach marginally better in terms of ease of use with a mean value of 3.57 compared with users who preferred the instruction training approach, who scored a mean value of

3.52. Advanced users found the training environment marginally more easy to use with a mean value of 3.56 compared with the basic level users with a mean value of 3.53. When the independent variable learning style preference was analysed for ease of use, those with an activist learning style found the training environment to be easier with a mean rating of 3.66. Reflectors rated at a mean value of 3.49, theorists at a mean value of 3.63 and pragmatists at a mean value of 3.39.

When the interface and training approach combination was analysed, users who preferred the menu interface and the exploration training approach rated greater ease of use with this combination with a mean value of 3.72 on the 5-point scale. Of the other preferred combinations, the icon interface and instruction approach – yielded a mean value of 3.31, the mean value for the icon interface and exploration approach combination was 3.47 and the mean value for menu interface and instruction approach was 3.70.

When the preferred interface and determined categories of user combination was analysed, basic users who preferred a menu interface rated the ease of use of the environment with a mean value of 3.76 on the 5-point scale. Basic users who preferred the icon interface rated the ease of use with a mean value of 3.27. Advanced users who preferred the icon interface recorded the training environment easy to use with a mean value of 3.50, while advanced users who preferred the menu interface rated the ease of use of the environment exactly as the basic users who preferred menus, with a mean value of 3.76.

Finally, the data was analysed for the preferred training approach and categories of user combination. Advanced users who preferred the exploration approach rated the environment easy to use with a mean value of 3.58. This was slightly higher than that of the instruction approach and basic level user combination (mean: 3.51), the instruction approach and advance level user combination (mean: 3.53) and the exploration approach and basic level user combination (mean: 3.57).

The following table is a summary of variables yielding superior mean for the outcome ease of use.

Table 4.6 Summary for Ease of use on training outcomes

Dependent Variable Combination	Variable	Mean	Deviation
Interface	Menu	3.71	0.73
Training Approach	Exploration	3.57	0.63
Level of user	Advance	3.56	0.59
Learning style preference	Activist	3.66	0.73
Interface x Training approach	Menu x Exploration	3.72	0.65
Interface x level of user	Menu x Basic	3.76	0.84
Training approach x level of user	Exploration x Advance	3.58	0.61

The above table indicates that the menu interface was a major determinant of the ease of use outcome as seen in its influence on a number of dependent variables. Exploration training approach also appears to have had an influence on the ease of use factor in this training environment.

Residual

In addition to these tests, the data were tested for residuals to ensure that they were correlated in terms of variables. The SPSS was used to compute residuals and the following plot provides the graphical representation of residuals.

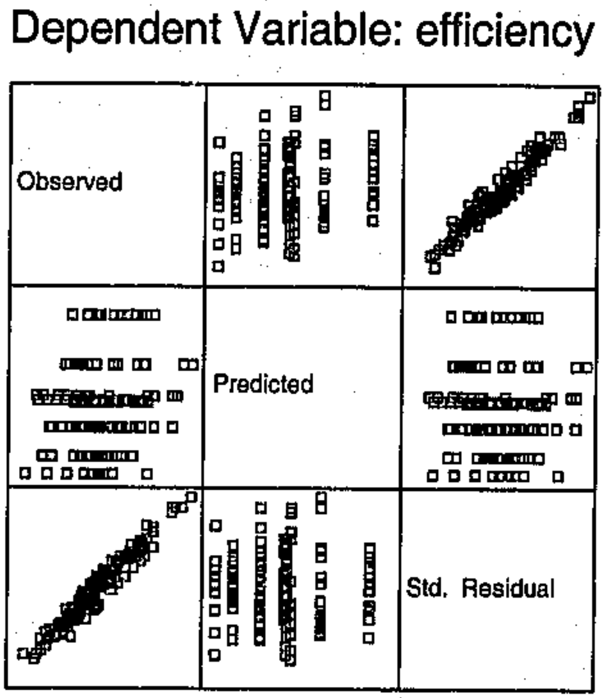


Figure 4.1 Efficiency Residual Plot

The top right cell and the bottom left cell of the nine-cell matrix provide the residual. The straight diagonal line indicates that the data is normally distributed. The line indicates that the relationship between the dependent variables and the independent variables is linear. In addition, it is possible to assume that the differences between the actual values and the estimated values are normally distributed. The line also indicates that the correlation is positive between the variables.

The following SPSS residual plot was computed for the outcome effectiveness.

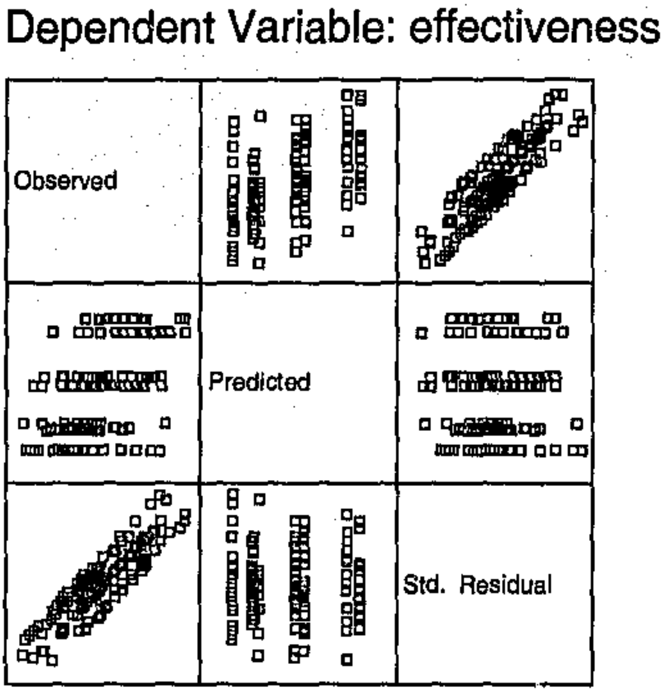


Figure 4.2 Effectiveness Residual Plot

The plot shows that the correlation is positive and linear. However, it is not as strong as for the efficiency outcome. This can be seen from the breadth of the points plotted. Instead of getting a tightly clustered line, the SPSS has produced a set of lines as the diagonal. This indicates that the correlation is less strong. It can therefore be concluded that the correlation is moderate.

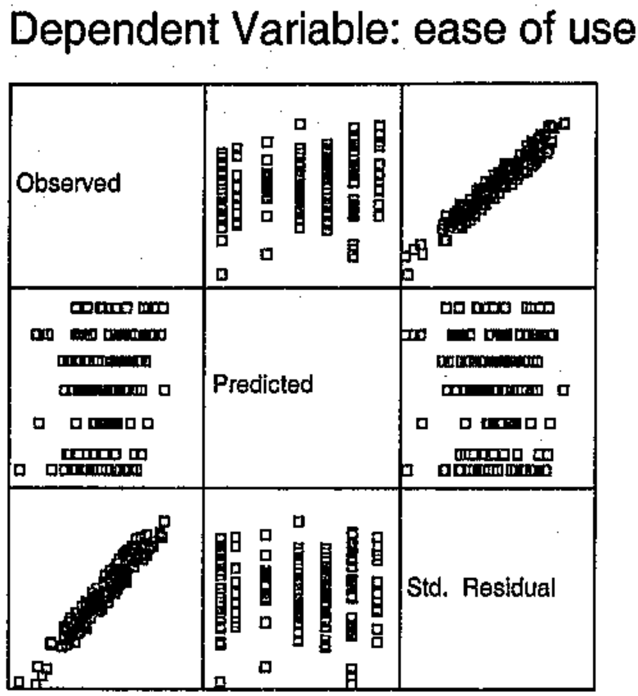


Figure 4.3 Ease of Use Residual Plot

The tightly correlated diagonal line indicates that the data for the outcome ease of use are normally distributed. The line also indicates that the relationship between the dependent variables and the independent variables is linear. In addition, it is possible to assume that the differences between the actual values and the estimated values are normally distributed. The line also indicates that the correlation is positive between the variables.

In summary, the data were analysed for validity, correlation, normal distribution and convergence. The tests indicated that the data were normally distributed and ready for analysis of variance for hypothesis testing. This is discussed in the next section.

Hypotheses Testing

The previous sections indicate justification for performing Analysis of Variance on the data for hypothesis testing. Aczel (1993) suggests two assumptions required of Analysis of Variance: (i) independent random sampling and (ii) normal distribution of data. With regard to the samples being independent, a discussion was provided in Chapter 3 as to the selection of the subjects. The normal distributions of the data were illustrated in the previous chapter. Thus, the assumptions were valid and hence the data can be tested using Analysis of Variance.

Zikmund (1994) states that when more than one independent variable is used, analysis of variance (ANOVA) is not preferred. Further, Aczel (1993) asserts that multivariate analysis of variance (MANOVA) is used to test for differences among populations with respect to more than one variable. In this study, the four independent variables – interfaces, training approaches, categories of users and learning styles – are interrelated, that is, they have an influence on each other. For instance, training approaches influence the preference for interfaces, and these preferences are, to some extent, influenced by prior experience. Therefore, for the purposes of Analysis of Variance, multivariate analysis was used in order to determine the effects of these independent variables in testing the hypotheses. When reporting the results of MANOVA, it is a general practice to use a concept called the p-value (Simon et al., 1996). Aczel (1993) defines the p-value as

"The p-value is the smallest value of significance, α, at which a null hypothesis may be rejected using the obtained value for the test statistic (p. 269)".

In order to perform MANOVA a significance level needs to be identified. For studies of this kind it is a customary practice to select a significance level of 0.05 (Aczel, 1993). This significance level is known as the *alpha*. In this study the *alpha* level was fixed at 0.05. When the p-value provided by MANOVA is less than the confidence interval (alpha), the null hypothesis is rejected.

The data for MANOVA consisted of subjects' interface preference, learning style preference, training approach preference, categories, efficiency scores, effectiveness scores and the ease of use opinion scores. Using this data, a full factorial model was prepared using SPSS to study the effects of the main variables and associated interaction between the variables so as to facilitate analysis of the interaction between interfaces and training approaches, interfaces and categories of users, training approaches and categories of users. The following sections provide the results of hypothesis testing using multivariate analysis.

Results of Multivariate Analysis (MANOVA)

Hypotheses 1 and 2

INTERFACES

- There will be no difference in quantitative (efficiency and effectiveness) training outcomes between icon-based subjects and menu-based subjects.
- There will be no difference in the subjective (ease of use) outcome between icon-based subjects and menu-based subjects.

This set of hypotheses tests the effect of interfaces in determining the three dependent variables – efficiency, effectiveness and ease of use. The two interfaces considered were icon interfaces and menu interfaces. SPSS was used to build a full factorial model using MANOVA. The results of the MANOVA indicate that the computer interface effect was significant in determining effectiveness ($p = 0.000$ and $F = 40.778$ for effectiveness). Therefore, only the hypothesis that there will be no difference in quantitative (effectiveness) training outcomes between icon-based subjects and menu-based subjects is rejected. The second hypothesis that there will be no difference in the qualitative (ease of use) outcome between icon-based subjects and menu-based subjects did not show any significance ($p = 0.221$, $F = 1.514$) and hence was not rejected.

To determine which interface was superior, data were analysed again with interface as the main factor. The following table resulted from such an analysis.

Table 4.7 Analysis of data – Interface

interface		Minimum	Maximum	Mean	Std. Deviation
icon	efficiency	11.78	76.80	37.10	13.72
	effectiveness	15.00	93.00	53.86	17.88
	ease of use	1.31	5.00	3.39	0.66
menu	efficiency	17.16	76.32	40.38	13.90
	effectiveness	11.00	64.00	37.70	10.99
	ease of use	1.74	4.96	3.71	0.73

As efficiency was calculated in terms of time and effectiveness was calculated in terms of score, a minimum value for efficiency indicates superiority while a maximum value for effectiveness indicates superiority. It can be seen from the above data that the icon interface group was more effective (see the mean values). When it comes to ease of use, the icon interface was only slightly better than the menu interface.

Hypotheses 3 and 4

TRAINING APPROACH

- There will be no difference in quantitative (efficiency and effectiveness) outcomes between the instruction-based subjects and the exploration-based subjects.
- There will be no difference in subjective (ease of use) outcome between the instruction-based subjects and the exploration-based subjects.

This set of hypotheses tests the effect of training approach on training outcomes. Participants were asked to nominate their preference for hands-on tasks in the experiment phase based on either the instruction or exploration training approach. The results of MANOVA indicate that there was no significance with respect to this independent variable in determining training outcomes. The MANOVA resulted in $p = 0.943$, $F = 0.005$ for efficiency, $p = 0.668$, $F = 0.185$ for effectiveness and $p = 0.995$ and $F = 0.000$ for ease of use. Therefore both the hypotheses (3 and 4) were not rejected. It is a customary practice not to perform further analysis on data when statistical significance was not established (Zikmund, 1994). Therefore, no further analysis was performed due to insignificance of these hypotheses.

Hypotheses set 5 and 6

CATEGORIES OF END USERS

- There will be no difference in quantitative measurement (efficiency and effectiveness) between basic level subjects and advanced level subjects.
- There will be no difference in subjective measurement (ease of use) between basic level subjects and advanced level subjects.

This set of hypotheses examines the effect of categories of end users. The two categories of users, basic and advanced, were based on subjects' prior knowledge and experience. The MANOVA results indicate that this variable was not significant in determining training outcomes. The MANOVA results were $p = 0.530$, $F = 0.396$ for efficiency, $p = 0.126$, $F = 2.373$ for effectiveness and 0.392, $F = 0.738$ for ease of use respectively. Because the p-values were higher than the significance level fixed, the hypotheses were not rejected. The data were not examined again because these hypotheses were not rejected.

Hypotheses 7 and 8

LEARNING STYLE PREFERENCES

- There will be no difference in quantitative measurement (efficiency and effectiveness) due to learning style preferences.
- There will be no difference in subjective measurement (ease of use) due to learning style preferences.

These two hypotheses examine the effect of learning style preferences on training outcomes. Participants were allocated one of four learning styles based on their responses to a questionnaire. The MANOVA results indicate that effectiveness is significant at 0.05 alpha-level with $p = 0.035$, $F = 2.961$. Therefore this part of the hypothesis 7 was rejected. Efficiency and ease of use outcomes did not show significance ($p = 0.611$, $F = 0.607$ for efficiency and $p = 0.191$, $F = 1.606$ for ease of use). Hypotheses reflecting these components were not rejected. The data was further analysed to examine the effect of this variable with respect to effectiveness training outcome.

Table 4.8 Analysis of data – Learning style preference

lstyle		Minimum	Maximum	Mean	Std. Deviation
Activist	effectiveness	11.00	85.00	47.86	16.26
Reflector	effectiveness	15.00	93.00	47.64	18.15
Theorist	effectiveness	15.00	93.00	45.33	16.277
Pragmatist	effectiveness	17.00	81.00	42.05	16.61

Due to statistical significance in effectiveness outcome, a Post Hoc test was conducted to determine which learning style preference was superior. However, the test did not yield significance for learning style preference between groups for effectiveness. One reason could the unequal and small group sizes. A maximum value for effectiveness indicates superiority and it can be seen from the above table that users determined as having an activist learning style is most effective, closely followed by users determined as having reflector learning style. Users determined as having the theorist learning style were the least effective.

Hypothesis 9 and 10

INTERACTION: INTERFACE x TRAINING APPROACH

- There will be no difference between icon-based subjects given exploration training and other interface/training subjects in terms of quantitative measurements (efficiency and effectiveness).
- There will be no difference between icon-based subjects given exploration training and other interface/training subjects in terms of subjective measurements (ease of use).

This set of hypotheses examines the combined effect of interface and training combination on training outcomes . The MANOVA results returned $p = 0.491$, $F = 0.477$ for efficiency, $p = 0.605$, $F = 0.269$ for effectiveness and $p = 0.997$, $F = 0.000$ for ease of use respectively. Therefore, these hypotheses were not rejected. The data were not analysed further for descriptive statistics.

Hypothesis 11 and 12

INTERACTION: INTERFACE x CATEGORIES OF END USERS

- There will be no difference between the icon-based subjects with basic level of knowledge and other interface/level subject in terms of quantitative measurements (efficiency and effectiveness).
- There will be no difference between icon-based subjects with basic level of knowledge and other interface/training subjects in terms of subjective measurement (ease of use).

This set of hypotheses examined the interaction effect of interfaces (icon and menu) and categories of end users. The two interface types did interact with either category of end user in determining training outcomes. The MANOVA resulted in $p = 0.539$, $F = 0.379$ for efficiency, $p = 0.163$, $F = 1.971$ for effectiveness and $p = 0.165$, $F = 1.954$ for ease of use. The hypotheses were therefore not rejected.

Hypothesis 13 and 14

INTERACTION: TRAINING APPROACH x CATEGORIES OF END USERS

- There will be no difference between instruction based training to participants in the basic category and other training/level subjects in terms of quantitative measurements (efficiency and effectiveness).
- There will be no difference between instruction based training to participants in the basic category and other training/level subjects in terms of subjective measurement (ease of use).

The above set of hypotheses examines the interaction effect between training approaches and categories of end users. The two training approaches (instruction and exploration) interacted with two categories of end users to determine training outcomes efficiency, effectiveness and ease of use. The MANOVA results indicate that $p = 0.088$, $F = 2.949$ for efficiency and $p = 0.044$, $F = 4.138$ for effectiveness indicating significance. Therefore, hypothesis 13 that there will be no difference between instruction based training to participants in the basic category and other training/level subjects in terms of quantitative measurements (effectiveness) was rejected. For the training outcome ease of use, $p = 0.688$, $F = 0.162$ indicate lack of significance and hence hypothesis 14 was not rejected. When the descriptive statistics were computed to examine the effects of efficiency and effectiveness, the following table was generated.

Table 4.9 Analysis of data – Training approach x Level of user

training	level		Minimum	Maximum	Mean	Std. Deviation
Instruct	Basic	efficiency	14.98	67.68	35.56	11.26
		effectiveness	11.00	81.00	41.40	16.90
	Advance	efficiency	11.78	76.80	43.33	17.68
		effectiveness	19.00	93.00	48.81	18.33
Explore	Basic	efficiency	16.49	59.82	39.36	11.06
		effectiveness	24.00	93.00	51.96	17.46
	Advance	efficiency	13.03	76.32	39.03	14.66
		effectiveness	15.00	80.00	46.15	14.33

It can be seen from the above table that the instruction – basic combination was superior in terms of efficiency (35.56) but the exploration – basic combination was superior in terms of effectiveness (51.96). The exploration – basic combination was superior in ease of use.

The following table provides a summary of the hypotheses testing and decisions based on the multivariate analysis:

Table 4.10 Rejection/Acceptance of Hypotheses

Hypothesis	*Efficiency*	*Effectiveness*	*Ease of use*
INTERFACES There will be no difference in quantitative training outcomes (efficiency and effectiveness) of icon-based subjects and menu-based subjects.	0.063 /do not reject	0.000/**reject**	
There will be no difference in the qualitative outcome (perceived ease of use) of icon-based subjects and menu-based subjects.			0.221/do not reject
TRAINING APPROACH There will be no difference in quantitative outcomes (efficiency and effectiveness) between the instruction-based subjects and exploration-based subjects.	0.943/do not reject	0.668/do not reject	
There will be no difference in qualitative outcome (perceived ease of use) between the instruction-based subjects and the exploration-based subjects.			0.995/do not reject
CATEGORIES OF END USERS There will be no difference in quantitative outcomes (effectiveness and efficiency) between basic level subjects and advanced level subjects.	0.530/do not reject	0.126/do not reject	
There will be no difference in qualitative outcomes (ease of use) between basic level subjects and advanced level subjects.			0.392/do not reject
LEARNING STYLE PREFERENCES There will be no difference in quantitative measurement (effectiveness and efficiency) due to learning style preferences.	0.611/do not reject	0.035/**reject**	
There will be no difference in qualitative measurement (perceived ease of use) due to learning style preferences.			0.191/do not reject

INTERACTION: INTERFACE x TRAINING APPROACH			
There will be no difference between icon-based subjects given exploration training and other interface/training subjects in terms of quantitative measurements (effectiveness and efficiency)	0.491/do not reject	0.605/do not reject	
There will be no difference between icon-based subjects given exploration training and other interface/training subjects in terms of qualitative measurements (ease of use)			0.997/do not reject
INTERACTION: INTERFACE x CATEGORIES OF END USERS			
There will be no difference between icon-based subjects given basic level of knowledge and other interface/level subjects in terms of quantitative measurements (effectiveness and efficiency)	0.539/do not reject	0.163/do not reject	
There will be no difference between icon-based subjects given basic level of knowledge and other interface/level subjects in terms of qualitative measurements (ease of use)			0.165/do not reject
INTERACTION: TRAINING APPROACH x CATEGORIES OF END USERS			
There will be no difference between instruction based training to participants in the basic category and training/level subjects in terms of quantitative measurements (effectiveness and efficiency)	0.088/do not reject	0.044/reject	
There will be no difference between instruction based training to participants in the basic category and other training/level subjects in terms of qualitative measurements (ease of use)			0.688/do not reject

Summary of Hypotheses Testing

Main Effects

Interface

The rejection of hypothesis that there will be no difference in quantitative (effectiveness) training outcomes between icon-based subjects and menu-based subjects asserts that interfaces play a crucial role in determining training outcomes efficiency and effectiveness. The initial proposition, that interfaces play a determinant role in deciding training outcomes, is established by this study. The efficiency outcome was not significant ($p = 0.063$) and effectiveness was significant at $p = 0.000$. The outcome ease of use was not significant in this study ($p = 0.221$). This study provides evidence that the menu interface is efficient and effective.

Training Approach

This study did not provide any evidence to reject the hypotheses that there would be no difference in quantitative (efficiency and effectiveness) outcomes between the instruction-based subjects and the exploration-based subjects; that there will be no difference in qualitative (ease of use) outcome between the instruction-based subjects and the exploration-based subjects.

Categories of end users

This study did not provide evidence to reject any of the null hypotheses to determine whether prior knowledge and experience play any role in determining training outcomes. Statistical significance was not established to refute the hypotheses. However, the result was somewhat misleading. The efficiency achieved by basic users cannot be taken as conclusive because most of them were not able to complete the full range of tasks because of lack of knowledge. On the other hand, there is clear evidence to conclude that advanced users were effective. This is because, effectiveness was based on the number of keystrokes performed irrespective of whether a task was completed or not. The number of keystrokes established the actions taken in completing a given task. When it comes to efficiency, it is not clear whether the advanced users paused and used more time because of information processing sequences or were affected by lack of knowledge. Therefore, it can be concluded that advanced users were relatively effective and reasonably efficient. These users also found the software application easy to use.

Learning style preferences

The hypothesis on the effectiveness of learning style in determining training outcomes shows significance in this study. The other null hypotheses, concerning efficiency and ease of use, could not be rejected due to insufficient evidence.

Interaction Effects

Interface x Training approach

This study was not able to reject any of the hypotheses for the interaction effect between interfaces and training approaches because the MANOVA did not show any significance.

Interface x Categories of end users

This study was not able to reject any of the hypotheses for the interaction effect between interfaces and categories of end users because the MANOVA did not show any significance.

Training approach x Categories of end users

The hypothesis in terms of effectiveness ($p = 0.044$) was significant for this combination. However, efficiency ($p = 0.088$) was not significant. Therefore, the hypothesis in terms of effectiveness was rejected. However, there was no evidence to reject the hypothesis on ease of use ($p = 0.688$). The combination of instruction approach and the basic users generated the minimum overall time and hence was more efficient. The combination of exploration and basic users generated the maximum score for effectiveness and hence was more effective than any other interaction group. When the main effect training approaches were analysed, the instruction approach yielded greater efficiency and the exploration approach yielded greater effectiveness. This pattern appears to have repeated in the interaction combinations.

Conclusion

In this chapter, the data was verified for reliability and validity. Reliability tests such as split-half method were performed to ensure data reliability in order to conduct hypotheses testing. Due to the interdependence of independent variables, MANOVA was used in this study to analyse data for hypotheses testing. The results of hypotheses testing were reviewed with the descriptive data again to identify the superiority of the variables used in the study. Chapter 5 will provide a detailed discussion to the possible causes for the results presented in this chapter.

CHAPTER 5 – DISCUSSION AND CONCLUSION

In the previous chapter, it was concluded that interfaces play a significant role in determining the efficiency and effectiveness training outcomes but not the ease of use training outcome. Similarly, the interaction effect between training approaches and categories of end users also plays a significant role in determining training outcomes efficiency and effectiveness. Furthermore, learning style preferences play a significant role in determining training outcome effectiveness. In this chapter, discussion is provided to explain the results of the data analysis. The chapter is organized in terms of the main effects and interaction effects of the independent variables.

Interfaces

Efficiency and effectiveness

The results of statistical tests provided strong evidence to support the hypotheses that interfaces play a crucial role in determining the training outcome effectiveness. There is no statistical evidence that efficiency factor is significant in determining training outcomes in terms of interfaces. Users who preferred icons were shown to improve in effectiveness compared with the users who preferred menu interfaces and this benefit was also significant in statistical terms. These findings are in agreement with other studies such as Chin (1984), Fryer (1991), Shneiderman (1982) and Walkenbach (1992) which have established that direct manipulation interfaces such as icons enhances user performance. However, it should be noted that these studies have established the superiority of icon interfaces in an operating system environment and not in an application environment. This difference is worth noting because in an operating system environment tasks are handled on a component basis such as moving a file to a recycle bin. In an application environment, as used in this study operations need to be in a sequential order to accomplish a given task and hence continuity between operations is essential. Nonetheless, this study found that using icon interfaces enhanced performance better than using menu interfaces in the same way as Chin (1984) and others found in an operating system environment.

In EUC literature, the three studies that found such direct manipulation interfaces superior were criticised for their lack of theory in explaining why such an outcome was realised (Dumais & Jones, 1985; Michard, 1982; Rohr, 1984). The superiority of icon interfaces in this study can be explained using Assimilation Theory. The proposition of Assimilation Theory (Ausubel & Robinson, 1968) is that, in order to achieve meaningful learning, an individual must integrate new knowledge with existing knowledge available in long-term memory. In order to achieve this integration, however, the individual must first possess an appropriate assimilative context. This context, in turn, provides a basis for thinking about and reasoning with the new knowledge. In this study, the icon interfaces provided the appropriate assimilative context by presenting subjects with an on-screen conceptual model of the system. For example, certain tasks of the project management application such as 'linking sub-tasks' are provided by the icon interfaces readily available on screen. Subjects who preferred icon interfaces easily understood the meaning of these interfaces and this understanding led to greater effectiveness. Menus did not provide this same understanding, as users needed to interpret the menu commands to arrive at some form of understanding.

Bostrom et al. (1990) states that application interfaces play a crucial role in developing mental models by providing an internal representation of the system and, in this study, icons portray functions of Microsoft Project better than menus. In other words, icon interfaces provide conceptual models of the functions of Microsoft Project by providing the meaning of the interface language on screen. Further, users following the 'mapping via training'[47] path use these icon interfaces to easily form a conceptual model of various functions of the application. The advantages of using conceptual models for learning computer skills has been confirmed in a number of studies (Borgman, 1986; Davis & Bostrom, 1993; Mayer, 1981; Sein & Bostrom, 1989).

A significant additional advantage of icon interfaces over menu interfaces is that they allow users to work directly with on-screen representations and to draw strong analogies with concrete objects such as recycle bins and diskettes. For instance, to save a file, icon interfaces in a Windows environment provide an icon

[47] 'Mapping via training' was discussed in the literature review in relation to Bostrom et al.'s model. It relates to mental model of a computer system formed by users as a result of training.

representing a floppy diskette. Users immediately understand the meaning of such icons which enables them to readily understand and undertake a task. Hutchins et al. (1986) suggests that this can lead to a substantial reduction in a user's cognitive processing load and Shneiderman (1982) states that this can reduce the cognitive load placed on information processing. This reduction could have yielded better results for users who preferred icon interfaces.

According to Davies et al. (1989), support for icons over menus can be found in terms of two key factors: semantic distance and articulatory distance. Semantic distance refers to the relationship between a user's conceptualisation of an operation and the mechanism that the interface provides for carrying it out. When an interface closely matches with the user's conceptualisation, it is said to be semantically direct. The icons in this study were semantically direct because they allowed subjects to perform tasks in ways that they would naturally experience them. For example, when subjects who preferred icon interfaces wanted to link tasks (this was represented as a picture of a 'chain' in Microsoft Project), which was one of the activities in the hands-on exercise, they performed a simple operation using icons: they selected the tasks to be linked using the mouse, then they clicked on the link icon available in the software application. Menu based subjects, on the other hand, had to translate this intention into a sequence of steps that matched the conventions of the interface language: first they had to ascertain the location of the menu item, select the menu option using the mouse, navigate the menu to select the correct sub-operation, click on that operation, dispose of the menu, and then verify that the operation was complete. In other words, when subjects used menus, they had the burden of translating their intentions into a process that the application recognised. For icon subjects, the interface did most of the work. This was clearly demonstrated in the effectiveness factor.

In terms of efficiency outcome, due to the newness of the MS Project applications, subjects needed to translate their intentions into actions. Irrespective of the availability of interfaces, the translation process was time consuming and equally complicated to subjects. It can be assumed that the relative newness of the application domain (MS Project) provided no distinctive advantage to users with their previous knowledge and experience. This perhaps has contributed to the lack of significance in efficiency. Therefore, the hypothesis that both subjects (icons and menus) would be equal in efficiency factor was not showing any statistical significance and hence was not rejected.

Similarly, in order to interpret output, subjects who preferred icon interfaces needed to do less translation than menu subjects. For instance, when the files were saved, subjects using icons saved the file onto the desktop. The Windows operating system provided a readily visible representation of the file with its name on the desktop to indicate that the file has been successfully saved. On the other hand, when using menus, subjects in this study had to choose an appropriate folder where they had write permission, provide the correct extension and then save the file. It was observed while replaying the ScreenCAM files that, some subjects were confused by the 'save' menu option and the 'save as' menu option as both of these menu options represented similar functions with subtle differences. Moreover, these two menu options are situated next to each other in Microsoft Project File menu, creating a possibility for the wrong choice by users. Further, while using the 'save' option in Microsoft Project, subjects who preferred menus had to comply with certain requirements enforced by Microsoft Project such as the 'baseline' option in order to save the project as a specific version. These requirements were not found by icon interfaces because the interface language incorporates these options and reduces the burden placed on the users. The complexity of the operation with menus resulted in subjects carrying out wrong actions. Further, to verify that the file had been saved properly, they had to use operating system commands and explore the folder and ensure that the file was available. This increased the number of operations performed to carry out a task and hence created an increase in semantic distance. This was obviously reflected in the effectiveness outcome for users who preferred menu interfaces. While the number of keystrokes using icons is significantly different, the same can't be said for the time. The time to translate their intentions into actions is almost equal and this is reflected in the efficiency outcome.

The second factor, articulatory distance, refers to the relationship between the meaning of an expression in the interface language and its form. Interfaces that provide non-arbitrary relationships between their representation and their meaning are more direct and therefore have less articulatory distance than interfaces that do not (Davies et al., 1989). One way to provide such directness is to base operations on users' intentions. Icon interfaces enable this with operations such as drag and drop to move tasks and rearrange them. For example, if users want to rearrange the position of tasks in a project, then they can select the task that needs rearrangement, drag it to a new cell in the application and drop the task in the new position. These mimic the user's intention to move things from one place to another. The interface language takes the responsibility of re-numbering the tasks to reflect their correct order and thereby reduces the burden placed on the users. Therefore, there is relatively little articulatory distance employed in the process. Menu interfaces, however, are not as direct because they use fairly arbitrary relationships to link expressions and commands. For example, in Microsoft Project, to move a task to a new position using menus, users first need to 'cut' the task using the correct menu option, insert an empty cell by executing the appropriate menu selection and then paste the task into the new position in the project environment.

Similarly, the menu option 'timescale' is provided to alter the working time – weeks, months, days or hours. Users need to know the location and position of the menu command in the application's menu bar to conduct a task that involves the time schedule. Once the menu command is found, the default settings need to be altered to reflect the correct option, such as week. Subjects have to understand how the menu items are grouped, the hierarchy of the menu items as well as how to alter the settings in order to successfully carry out the task. This lack of directness was noted in this study when many subjects exhibited frustration at not being able to find the correct command strings for performing some components of the hands-on tasks. This resulted in a poor relationship between the user's intention and the form of the interface language which supports such intentions. Therefore, users who were not able to manipulate menus because of insufficient knowledge in the first place were not helped by close articulatory distance to support their intentions. Icons provided this.

Another advantage of using icon interfaces is that they enhance recall of simple operations (Davis & Bostrom, 1993; Sein et al., 1993). For example, once subjects were able to successfully link two tasks, they could easily remember the 'link' icon to perform this operation to link other tasks when required. Due to the smaller semantic and articulatory distance of icons, subjects were able to translate their meaning into operations easily. This in turn enabled them to recall functions portrayed by icons more easily than those who chose the menu commands. Users who performed the link operations using menu commands were not always able to remember the sequence of steps involved in the operation. In other words, the articulatory distance was more direct when icons were used in performing a task.

The findings of this study differ from those of Carrol & Rosson (1995) who found menus to generate better outcomes than command types. This study found icons to be superior. One possible explanation is the platform on which Carrol & Rosson's training was provided. Carrol & Rosson (1995) used a DOS platform where commands were entered in the form of text strings using a text editor or commands were selected using a menu system. Users in the Carrol & Rosson's study found menus to be better because users found menus easy to use. Further, menus were found to be superior because there is no provision for typographical errors while selecting commands. On the other hand, this study used a Windows platform. In this study commands can be chosen from a limited set of options using icons in a Windows environment. These icons provide a visual representation of functional aspects of commands, providing better articulatory distance than menus. Any limitation[48] in accessing menus would have biased the results of this study.

Ease of use

Despite this study supporting the superiority of icon interfaces in effectiveness, there is no evidence to support the superiority of icon interfaces in terms of ease of use. In fact, subjects who preferred menu interfaces were deemed to be better compared to subjects who preferred icon interfaces in the qualitative ease of use outcome. Therefore, it can be assumed that subjects who preferred icon interfaces did not find them easy to use. This can be explained by the difficulties encountered in applying icon interfaces to certain complex situations where users had to perform a combination of steps rather than a single icon click. For instance, when time scales needed adjustment, icon subjects had the option to move the timescale by the 'drag and drop' method. On the other hand, to arrive at a precise time scale, icon users needed to make necessary modifications to the time scale presented on screen by Microsoft Project. But, despite the on-screen facilitation of time-scale adjustments, it was noted while replaying ScreenCAM files that, users who preferred icons were not fully conversant with the various details of time-scale adjustments, such as changing

[48] This is further elaborated in Chapter 6.

the project schedule from month to week, found icon interfaces difficult to use with respect to this method. In these cases, subjects who preferred icon interfaces would not have found these interfaces easy to use. Subjects who preferred menu interfaces, due to information cues provided by the application, would have found the application easy to use under these circumstances.

Novel situations require manipulation plans and these in turn require searching both short-term memory and long-term memory for information to match with the information available on hand (Ausubel & Robinson, 1968). Information searching in novel situations needs to be disciplined and logical. Menu interfaces provide assistance in searching for commands based on hierarchical grouping, which icon interfaces do not. Therefore, users who prefer menu interfaces might judge the application to be easier to use. The project management software application was a novel situation for the users in this study and menus may have provided a better way of exploring the command strings required to perform a task. Further, the command strings found in menu options may have enabled users to understand the context in order to explore further. So, subjects who preferred menu interfaces found greater 'ease of use'. This is in spite of establishing icon interfaces to be quantitatively more efficient and effective. Thus, in this study, it was observed while replaying the ScreenCAM files that, whenever subjects who preferred icon interfaces found the interface to fail to provide apparent and trivial solutions attempted to use menus despite their preference for icons and subsequently found menus easy to use in novel situations. This is further highlighted in the next chapter.

Another reason for menus being considered easy to use was the language. Menus were made up of English text strings and, in this novel situation, assisted subjects to assimilate meaning. The text strings, which provide the meaning of the interface language in the menu options helped subjects to translate a given situation into an operation. The menus helped subjects to derive the meaning of an interface language by linking their existing knowledge to the context. So, while the interface language provided by icons was deemed to be more useful in trivial tasks, interface language provided by menus were easier to use in complex tasks. This is because of the inability of icons to actually represent interface language.

The difference between the findings of this study and the study by Dumais & Jones (1985) that has established the superiority of 'ease of use' of icon interfaces may be due to the fact that subjects in Dumais & Jones' study were not categorised based on experience or knowledge and these subjects simply retrieved uniformly shaped objects similar to icons. The retrieval involved just recalling shapes and did not involve complicated operations leading to meaningful learning. By contrast, subjects in this study manipulated a range of different icons on a computer screen instead of uniform 3-dimension objects. For example, in Microsoft Project, icons range from a commonly available shape such as a floppy diskette icon to an uncommon shape such as a link icon. Similarly, the difference between the findings of this study and the study by Davis & Bostrom (1993) that has established the superiority of icons in terms of ease of use may be due to the fact that in the Davis & Bostrom's (1993) study, subjects performed short, discrete sequences of operations using icons. These short operations involved simply recalling pieces of information and, again, did not lead to a cohesive set of operations, leading in turn to meaningful operations. By contrast, subjects in this study performed relatively complicated operations that required them to formulate and execute manipulation plans. Menus appear to facilitate these complicated operations in a better way than icons in the application environment of this study. These would have enabled the subjects in this study to rate menu interfaces easier to use.

It has been argued that in novel situations users integrate new knowledge with existing knowledge to complete a given task (Sein & Bostrom, 1989). This is the premise of Assimilation Theory which states that to arrive at meaningful learning, a learner should be able to integrate existing knowledge to new situations by understanding the relationship between the new and the existing knowledge. In novel situations, tasks often involve the application of problem solving skills to determine which information is relevant and how to use it to achieve desired results. Usually, this involves a series of basic commands. In this study, while subjects who opted for icon interfaces scored better quantitatively, these subjects have found icon interfaces less easy in subjective terms. One reason appears to be the difficulties in translating users' intentions with icons alone. Despite the fact the subjects who preferred icon interfaces would also have been able to integrate their existing knowledge with new knowledge, the interface language was not adequate to accomplish the tasks due to the limited interface language presented by the icons on the screen. While replaying ScreenCAM files, it was noted that when users approached novel tasks using icons, due to the limited representation with the icons, they were not able to successfully accomplish the tasks. Subjects who preferred menu interfaces used their existing knowledge and integrated the knowledge gained from the available menu options in the application to derive new knowledge in order to accomplish novel tasks. This was because menus provided more informative options to users and hence they responded that menus were easier to use.

Based on the above paragraphs, it can be asserted that users who preferred icons scored better quantitative results than users who preferred menus because of the assimilation of context through the representation of the icons. However, this study also indicates that when the tasks become complicated, icons are limited in representing this complexity and menus appear to be providing better solutions for tasks accomplishments. This is reflected in the subjective 'ease of use' survey where users rated menus to be better compared with icons.

Training Approach

The results of statistical tests provide evidence that there is no difference between training approaches in determining training outcomes efficiency, effectiveness and ease of use. The statistical tests on the training approaches variable indicates that the results of the three training outcomes for both the preferences (instruction and exploration) were similar. This study is therefore not able to confirm the superiority of either approaches in determining training outcomes.

The results of data analysis show that subjects who preferred the exploration approach scored better in effectiveness (48.31 vs 44.06). These subjects also found the exploration approach to be marginally easier to use. But when it comes to efficiency, both training approach groups showed similar results (38.36 and 39.15 for instruction and exploration respectively). However, the results were not statistically significant for the three outcomes – efficiency, effectiveness and ease of use.

Efficiency and effectiveness

A previous study by Davis & Bostrom (1993) established that the instruction approach was superior in effectiveness to the exploration approach in EUC training. But two other studies have established that the exploration approach was actually superior in effectiveness (Carrol & Mazur, 1986; Olfman & Mandviwalla, 1994). It has also been found in EUC training that when the complexity of tasks increases, the superiority of the exploration approach appeared to be approaching statistical significance (Davis & Bostrom, 1993). However, this study did not find support for any of these findings.

The lack of statistical significance concerning the training outcomes effectiveness and efficiency for the variable training approaches may be due to the fact that the training materials were produced to be as close as possible in terms of their tasks and complexity. Further, while the materials featured ample hands-on use and problem solving exercises, neither training approach focused on teaching the syntax of the application software. Subjects used the training materials to understand the operations of the application. To facilitate this, the training materials provided general rules and specific examples of how to handle a specific situation within the scope of the application software. Therefore, it can be assumed that the level of understanding of the functional operations of the application software resulting from the training materials would be the same. This could have impacted on the training outcomes and hence the lack of significance indicating 'no difference' between training approaches in determining training outcomes.

Another possible explanation for the lack of significance is the application domain. While previous studies have considered operating systems (Davis & Bostrom, 1993), spreadsheets (Carrol & Mazur, 1986) and other application domains (Olfman & Mandviwalla, 1994), this study considered a project management application. Project management applications are inherently complex. Subjects need to understand the basic concepts of project management and then to understand the meaning of the functional elements of the software to successfully perform an operation. This is not the case in a spreadsheet application because the concepts at the basic levels are reasonably straightforward in that environment. Due to the complex nature of tasks found in project management applications, it is not always possible to readily convey the meaning of the tasks through training materials. In this study, training materials provided information regarding the operational sequences of tasks and not their meaning. While subjects were inducted in the meaning of some icons and menu commands, the complete meaning of how a specific icon works in a given situation was not explained in the training materials. Therefore, subjects in this study needed to determine independently whether a menu command or icon was available and suitable to carry out a task. This could have resulted in some form of 'deduction' and subjects who preferred exploration training could have gained some advantage compared with subjects who preferred instruction training. This is reflected in the average scores for effectiveness where subjects who preferred exploration training have scored marginally better than those who preferred instruction training.

Previous studies have found exploration training to be superior over instruction training for meaningful learning (Carrol & Mazur, 1986; Sein & Bostrom, 1989). According to Assimilation Theory, for meaningful learning to occur, individuals must search long-term memory to retrieve appropriate anchoring ideas or contexts. But, studies conducted by Gentner & Gentner (1983), Gick & Holyoak (1983) and Davis & Bostrom (1993) suggest that, unless learners are provided with cues to help them retrieve appropriate concepts, they will often be unable to do so. Therefore, it is possible to assume that subjects with a preference for instruction training would have encountered difficulties in retrieving information during the hands-on task experiment because of want of information cues. On the other hand, subjects with exploration training would have generated necessary information cues on their own due to the very nature of exploration through the trial and error options provided to them. This is particularly true of learners, such as beginners, who have no prior experience in the given learning domain because the trial and error would have helped them to explore and then understand aspects of the application. In this study, subjects were given with an option to nominate their preference for either of the training approaches. Subjects nominated their preference after the training session. Despite the preference to a training approach, this study did not exercise any control over whether subjects actually used their preferred training approach in the experimental phase. In other words, there was no control over subjects to verify whether the nominated approach, indeed, was actually used while accomplishing tasks during the experiment. Therefore, it is possible that subjects mixed the training approaches while accomplishing the tasks. The results of this study should be interpreted with this point in mind. This is again reflected in the average scores for efficiency where subjects who preferred exploration training have scored marginally better than those who preferred instruction training, however not significantly so.

The lack of significance effect for the variable training approach contradicts the findings of Carrol et al. (1987) who have asserted that training approaches are significant in EUC training. Bohlen & Ferrat (1997) have also claimed this. Therefore, specific study related factors might have been responsible for the outcomes reported here. One such factor may have been the background of subjects. All of the subjects in this study were tertiary students in the Science discipline. It is highly likely that most of them were accustomed to an on-going structured learning environment. As a result, they may have been less comfortable with the short training that was provided in this study. Douglas & Moran (1982)[49] also note this as a reason for the lack of significance for training approaches in their study.

In the previous studies that have found exploration training superior, the professional and work backgrounds of the subjects may have prepared them for the more intensive and unstructured learning and problem solving environments that were representative of the exploration learning conditions (Carrol & Mazur, 1986). In this study, despite categorising users based on their knowledge and experience, there was no statistical significance. However, one would expect exploration learning to yield significance based on Carrol & Mazur (1986) Study. The reason may be the subjects' background. Subjects who participated in this study did not have a project management background and hence it is possible to argue that both training approaches failed to have an impact on them. This is important because it suggests that simply providing users with opportunities to work with concepts may not bring out necessary results. For some subjects, trainers may need to provide learning environments that impose greater control.

Another possible explanation is that the advantages of exploration training may be realised when individuals are given longer periods of time to use the system. It was observed on the Lotus ScreenCAM files that , as the time increased, the complexity of tasks began to increase and exploration-training subjects found it relatively easy to accomplish these tasks. This may be one reason why the subjects who preferred exploration training showed marginally better results for the training outcome effectiveness. Carrol & Rosson (1995) has indicated support for this argument by establishing that that exploration training is superior. However, another

[49] Douglas et al (1982) conducted their research with students enrolled in biology.

study by Davis & Bostrom (1993) has shown that instruction approach is superior. One reason for such conflicting outcomes may be due to the fact that these studies were conducted under tight time constraints, say about 45 minutes of experiment. Therefore, future research needs to examine the effect of training time for both instructional and exploration approaches[50].

A further explanation for the lack of significant impact for training approach may be that certain trainee characteristics, which were unaccounted for, cancelled out any effects for training method. Sein & Bostrom (1989), for example, found that trainees who had a natural affinity towards 'images' tended to perform better in accomplishing tasks than those with an affinity towards 'text', regardless of the training method. Similar evidence is provided in this study. When the data was analysed for the combined effect of interface and training, it was found that subjects who preferred icon interface were more effective irrespective of the training method provided. Therefore subjects who preferred icons would have been aided in deriving the meaning of the interface language. But, despite the fact that icon interfaces convey the meaning of the interface language in a pictorial way, more subjects preferring a menu interface rated the application easy to use. As explained earlier, the only possible argument for this trend is that, as time and difficulty increased, subjects who preferred icons were restricted in the types of operations that they could perform and subjects who preferred menus had a better choice of options for this complex application. Therefore, trainee characteristic of affinity for images might have caused some bias in the results for the effect of training approach.

The lack of significance for training found in this study is supported by Olfman & Bostrom (1991) who conducted a study of exploration and instruction-based training using the Lotus 1-2-3 spreadsheet package. Olfman & Bostrom (1991) also found that learning groups exhibited little difference in their outcomes with these two training approaches. One reason suggested by Davis & Bostrom (1993), who reviewed Olfman & Bostrom's methodology, was that the tasks were not fully categorised on the basis of task complexity. In this study, despite the fact that the tasks were generated after careful consideration given to their complexity and sequence, the categorisation of tasks, such as near-transfer and far-transfer tasks, was

[50] Further details provided in the Limitations Chapter.

not done prior to the hands-on experimentation because of time constraints experienced by the researcher. Further, the researcher is not qualified in instructional design and hence was not able to assure that sufficient expertise was available for this purpose. Such a categorisation would have provided valuable information regarding how tasks were conducted, especially, near and far transfer tasks and this may have influenced the outcomes for the variable training approaches.

Another possible explanation for the lack of significance for the training approach variable may be self-training available to end-users. The current technological climate has seen considerable adaptation of computers to end users' needs and skills enabling users to train themselves. Evidence for this argument is the plethora of books to be found in bookstores which enable users to become familiar with instructions and which prepare them to explore software applications. This coincides with a marked increase in PC owners who have become familiar with a range of applications. Therefore the combination of user experience, the advent of PC applications and familiarity with PC functions might have biased the results of this study for the variable training approaches.

Ease of use

The average scores for the training outcome ease of use for the variable training approach were similar. This was despite the fact that the correlations for this element in the questionnaire were positive and strong when validated for reliability. In fact, it should be noted that while the other factors such as 'using the system' in the ease of use questionnaire were scored highly , the 'using training materials' component scored relatively low correlations. The correlation was statistically significant at $p = 0.000$. This is perhaps the result of complexity of the application rather than the training material itself. For example, when specific tasks were given to the subjects in a radically different environment such as project management, they appeared to struggle, despite their familiarity with various computing terms and operations. This was observed when playing back the ScreenCAM files. This is supported by Olfman & Mandviwalla (1994) who has suggested that rich text based conceptual elaborations, as in the exploration training, do not always assist users, and other studies (Davis & Bostrom, 1993; Sein & Bostrom, 1989) have indicated that subjects' existing knowledge is essential to handle complex tasks, as suggested by the

Assimilation Theory. Therefore, the step-by-step inductive processing facilitated by the instruction training was not adequate for building the concrete mental models required to understand the application. On the other hand, subjects who preferred exploration training may appear to have benefited from some form of concrete mental model because of the trial-and-error deductive processing facilitated by the exploration approach.

Thus, for the variable training approach, this study was not able to assert the superiority of either of the training approaches. While subjects who preferred the exploration training was more effective, the outcomes for efficiency and ease of use were similar for all subjects. When the ScreenCAM files were reviewed, it appears that as the duration and complexity increased, subjects who preferred the exploration approach, appeared to be better able to accomplish the given tasks.

Categories of users

The results of statistical tests provide evidence that there is no difference between categories of user in determining training outcomes efficiency, effectiveness and ease of use. This study is therefore not able to confirm the superiority of either category in determining training outcomes. Therefore none of the three outcomes effectiveness, efficiency and ease of use were statistically significant.

However, the descriptive analysis showed that basic users were somewhat more efficient (36.75 for basic vs 40.84 for advanced) and advanced users were somewhat more effective (47.24 for advanced vs 44.71 for basic). The ease of use training outcome was almost equal (3.53 for basic vs 3.56 for advanced).

Efficiency and effectiveness

Previous EUC studies have not considered the combination of efficiency and user category and hence it is not possible to compare these outcomes with other studies. However, the results in terms of effectiveness are partially supported by previous studies in EUC such as Carrol & Mazur (1986), who found advanced users to be effective and Olfman & Mandviwalla (1994), who found experience to play a significant role in determining effectiveness. One major difference between this study and other similar studies in EUC is the method of categorisation of users. While Carrol considered only experience for categorisation purposes, Olfman & Mandviwalla considered only prior knowledge for categorisation. In contrast, this study considered both of these (experience and knowledge) in order to arrive at the two categorizations, basic and advanced.

This study shows that while basic users were efficient, they were not effective, that is, while they achieved good time scores, they did make more errors than the advanced users. Advanced users scored better in terms of effectiveness and this may be due to their ability to utilise concepts in long-term memory. However, after a review of previous studies in EUC, one would anticipate that if basic users were efficient, then they would also be effective, because greater efficiency implies completing a task in a shorter span of time and this needs the correct decisions to be made to accomplish the tasks. This is particularly so in this study because the hands-on tasks were accomplished via a sequence of continuous, short operations. But this was not the case. While basic users were efficient, they were not effective. From playing back the ScreenCAM files, it was noted that as the task complexity increased, basic users were not able to arrive at the correct operational sequences. This has translated into incomplete tasks which were in turn reflected in the shorter time (efficiency) score but resulted in their not being effective because of a lesser number of keystrokes. However, there is no statistical data to support this argument. This argument has becomes evident again with the data for the interaction between categories of user and interface combination, which provided no statistical significance. While the interfaces were effective and efficient individually, the interaction with the categories of users yielded no significance. So, the variable user category should be driving these results.

While the basic and advanced users who preferred icon interfaces showed similar scores for efficiency and effectiveness, basic and advanced users preferring menus showed different scores for efficiency and effectiveness advanced users who preferred menu interfaces performed better in terms of efficiency and effectiveness. Therefore, it can be speculated that experience plays some sort of role in determining training outcomes and this may be because they are able to understand the 'menu' interface language. Such a result has not been suggested by previous studies in EUC.

Assimilation Theory may provides a justification for the above finding. For instance, when Mayer (1981) compared users who were provided with conceptual models with users who were not, he found that the former group performed better in complicated tasks that needed access to long-term memory. Despite the fact that the application domain was radically different in this study, the play back of ScreenCAM files indicated (by the delay in mouse or keyboard movement) that advanced users appear to recall information from their long-term memory to accomplish tasks accurately. This suggests that the advanced users had constructed a mental model with the help of their prior knowledge and experience and that this mental model enhanced their task performance. On the other hand, basic users appear not to have been helped with their understanding of certain complicated tasks because the mental models constructed by them would have been limited through lack of experience and associated knowledge.

One key difference between this study and earlier research that have tested the link between prior knowledge and training outcomes is that earlier studies have used a DOS environment where users entered commands at the operating system prompt level. In this mode, commands are entered as individual entities and hence it is difficult to establish the links between various command sequences. Therefore, the lack of links between command sequences may have hindered the forming of mental models because mental models need sequential, logical steps (Sein & Bostrom, 1989). In contrast, in this study, subjects selected commands from a given set of menu options in a Windows environment. Therefore, it is possible to suggest that interfaces in conjunction with knowledge and experience in a Windows environment facilitated meaningful learning. This was reflected in the statistical data analysis.

The data analysis indicates that both basic and advanced users who preferred icon interfaces performed equally well on tasks that could be accomplished using icons alone. However, from the replay of ScreenCAM files, it appears that, when there was a necessity to integrate new knowledge with existing knowledge to arrive at the more meaningful learning required for complex tasks, basic users were struggling. One reason could be that icons, while providing meaning for certain operations, were not helpful in facilitating the integration of this meaning with existing knowledge which was essential to complete a task which required a set of actions. Therefore, as the complexity increased, advanced users appeared to be more effective than basic users.

Ease of use

It should be noted that the ease of use measurement in this study shows no significance between the levels of users. One might argue that if users were able to form meaningful mental models, then they should have found the system to be easy to use because an understanding of the interface language is essential to construct a mental model. This study is not able to provide any support in this regard and hence it should be assumed that the results in terms of 'ease of use' are inconclusive.

Overall, the categorisation of users did not have any significant impact on the outcomes measured in this study. However, there appears to be some support for the hypotheses that prior knowledge plays a role in determining training outcomes. This is because when tasks became complex, prior knowledge appeared to have assisted advanced users in deriving sufficient new knowledge to achieve the tasks. However, this cannot be supported statistically.

Learning Styles

The results of statistical tests provided strong evidence to support the hypotheses that learning styles play a crucial role in determining training outcome effectiveness. However, there was no statistical significance for the hypotheses that learning styles are a major determinant for the training outcomes efficiency and ease of use.

Efficiency and effectiveness

The findings of this study in terms of effectiveness are in agreement with two other studies in EUC training (Bohlen & Ferrat, 1997; Sein & Bostrom, 1989). While Sein & Bostrom's (1989) study measured performances in terms of 'scores' calculated manually in given hands-on tasks and Bohlen & Ferrat calculated 'scores' in assignments and practicum, this study used automated tools to extract the score information and then showed statistical significance for differences in effectiveness due to learning styles. This is a major difference between the two studies mentioned and this study.

In addition to this, while both Sein & Bostrom and Bohlen & Ferrat based their instrument on Kolb's Learning Style Inventory (LSI), this study based its instrument on Honey & Mumford's Learning Cycle (LC). Further, Kolb's instrument has been questioned for its validity[51] in short-training studies, whereas Honey & Mumford's instrument has been widely accepted for short-training programs. Despite these differences, this study is in agreement with Sein & Bostrom that there is a difference in training outcome effectiveness due to learning styles.

In both Kolb's model and Honey & Mumford's model, an activist learning style refers to users who are able to put the concepts into practice. According to these models, the training enables activists to generate new concrete experiences. According to Assimilation Theory, to generate new knowledge, one must integrate

[51] This was discussed in the Literature Review where Ruble and Stout have established the non applicability of Kolb's instrument in Bostrom et al.'s study.

existing knowledge with knowledge acquired during learning. Thus, in this study, users who were determined as having an activist learning style had high scores for effectiveness suggesting that during training they were able to assimilate the conceptual knowledge and then apply it to accomplish the given tasks. Further, the activists have also rated the overall training environment easy to use, further supporting the suggestion that they understood the applications software.

The other hypotheses, relating learning style preferences to efficiency could not be rejected due to lack of statistical significance. In terms of efficiency, this study differs from Bohlen & Ferrat's claim that learning styles are significant for training outcome efficiency.

The findings concerning the variable learning style preferences can be explained as follows. Of the four learning style preferences, possibly, individuals with an abstract learning mode, such as theorists with the best efficiency scores, have the ability to discover the rules and structures inherent in a new domain such as the project management application. These individuals take an analytical and conceptual approach to learning, relying heavily on logical thinking and rational evaluation. At the opposite end of the spectrum are individuals with a concrete learning mode such as activists. They take an experience-based approach to learning, one that draws heavily on prior knowledge and experience. Learning a new application may prove to be time consuming for them simply because they have little or no prior referent experiences to draw upon and this is reflected in the efficiency outcomes, that is tasks took them longer. According to Honey & Mumford's model, activists are people who involve themselves in new experiences and respond to novel situations. Therefore, in a non-traditional application such as a project management environment, the activists were better able to accomplish tasks as shown in their higher effectiveness scores. According to Honey & Mumford (1992) learning style can change with training time because subjects can change their preferences based on experience gained while learning [52], however, this study would have not captured change in learning style due to its limited duration.

It is almost axiomatic that learning how to use an application can be accomplished best through actually using it. Previous studies (Bostrom et al., 1990;

[52] This is further discussed in Chapter 6.

Brancheau et al., 1985; Olfman & Mandviwalla, 1994) have stressed the need for letting novices experiment with the system which suggests that an active experimentation mode seems more suitable to learning an application than a reflective observation mode. It appears that in this study, activists were facilitated by experimenting with the application software and that this engagement has resulted in their higher effectiveness score. However, due to the relative newness of the application, these users seem to have needed more time to integrate new knowledge with existing knowledge, resulting in a higher time (efficiency score) than some of the other learning style preferences. This is evident from the statistical significance for the outcome effectiveness but not efficiency.

Ease of use

This study is not able to assert that there will be a difference in training outcome ease of use due to learning style preferences.

Therefore, as a result of the above discussion, this study could only partly support previous research on learning style preferences. But while previous studies have asserted that learning style is a consistent predictor in determining training outcomes, this study was not able to assert the statistical significance of this independent variable in terms of the three training outcomes, effectiveness, efficiency and ease of use.

Interaction Effects

In this study, the interaction effects were tested statistically for significance to determine whether the combined effect between the variables had any impact on the training outcomes. For instance, in the Data Analysis Chapter, it was shown that while the individual variables training approaches and categories of users were not statistically significant, the interaction between these variables provided statistical significance in terms of efficiency and effectiveness. Therefore, a discussion is provided here as to the possible reasons of such effects.

Interface x Training approach

The results of the statistical tests provided little evidence to support the hypotheses that the interaction between interface and training approach played a crucial role in determining training outcomes efficiency, effectiveness and ease of use. This study supports the outcomes of Davis & Bostrom (1993), Olfman & Bostrom (1991) and Sein et al. (1987) that the interaction between interface preference and training approach are not statistically significant in determining training outcomes. Therefore, it can only be said that the evidence was not sufficient to reject the hypotheses and that there was no difference between interaction groups in terms of training outcomes.

One possible explanation can be the use of project management application, which was relatively new to subjects. Therefore, despite attaining statistical significance in the independent variable interfaces, this study was not able to attain significant differences when this variable was combined with training approaches. It appears that training approaches negated the impact of interfaces on training outcomes.

In this study subjects chose their preferred interface and training approach, rather than being allocated to these training approaches and interfaces without any consultation. Further, this study examined subjects' prior knowledge and experience based on responses to a questionnaire. The subjects in this study were also put in a structured learning environment and this was not found in other studies such as Bohlen & Ferrat (1997). As a result, these factors could have influenced the outcomes of this study.

Interface x Category of End Users

This study did not find sufficient evidence to support the hypotheses that there would be a difference in training outcomes due to the interaction between interface and categories of end users. The statistical analysis shows that the categorisation of subjects plays an insignificant role in the overall interaction effect. However, when the data was examined, it was found that the results were not consistent. For example, advanced level users who preferred icon interfaces found the training environment easier to use than basic users. However, earlier it was reported that the combination of menus and advanced users was likely to find the overall environment easy to use compared with the combination of icon and advanced users. Despite this fact that advanced user rated icon interface easy to use (from table 6.7), and that advanced user x icon users scored the second best score for ease of use, the combination of basic users and users with preference for menu interfaces actually resulted in a greater ease of use score. This is not consistent. Therefore, the only possible argument is that this is an indication that the interaction has some effect on training outcomes.

It appears that the choice of interface plays a crucial role in determining the impact of this interaction. From the data analysis, it was evident that basic and advanced users who preferred icon interfaces scored better in terms of efficiency and effectiveness irrespective of their level of knowledge. When it comes to ease of use, more subjects who preferred menu interfaces found the overall environment easy to use and again the category of users does not appear to have any influence. Therefore, it appears that both groups of users combined their existing skills with knowledge acquired during training and this enabled them to manipulate the interfaces during hands-on experiment. However, these users appear to find the interface language provided by the icons inadequate for more complex tasks. So fewer of them rated this interface less easy to use. Therefore, it appears that user category did not play a major role in the interaction effect.

Another explanation is that this study categorised users on the basis of knowledge and experience while Carrol et al. (1987) categorised users based on their experience alone. While experience helps users to understand an application, when it comes to novel situations, conceptual knowledge is also needed to accomplish tasks (Mayer, 1981). This study, based on the suggestions provided by Mayer (1981), considered both experience and knowledge to arrive at the user categories of basic and advanced. Therefore, the knowledge and experience would have also enabled advanced users to use menus when needed as menus provide some facility to integrate new knowledge with existing knowledge. Therefore, we would expect these advanced users to have the knowledge and experience to translate the interface language provided by icons to perform the trivial functions in the application, by navigating menus. They would have also been able to accomplish complex functions in the application. Hence, the two factors (interface type and category) may have contributed to the results found in this study.

The key difference between this study and that of Davis & Bostrom (1993) who found this interaction combination to be significant, is the categorisation of users. Davis did not categorise users according to their knowledge and experience, considering them all to be novices. The failure to categorise users based on their knowledge and experience may have biased the results of previous studies in EUC. Further, it should be noted that while studies such as Davis & Bostrom (1993) considered relatively straightforward tasks such as moving files from one directory to another directory at the operating system level, this study required more complex project management tasks. So subjects needed to understand the principles of project management first and then implement them using the application. Hence, it is possible that prior experience combined with training provided would have influenced this interaction (interface and category).

Despite the fact that more advanced users who preferred icon interfaces found the training environment easy to use than basic users with the same preference for icons, they were not as efficient nor as effective as the latter group. Basic users who preferred icons scored the best results for the training outcomes efficiency and effectiveness. So, to some extent, advanced users who strictly used icons might also have been inhibited by the limitations of icons.

Training Approach x Categories of End Users

The outcome measure effectiveness was significant for the interaction effect of training approach and categories of end users. The outcome measures efficiency and ease of use were not significant.

While previous studies (Carrol & Mazur, 1986; Olfman & Mandviwalla, 1995) have asserted that the categorisation of users based on their experience is essential, these studies did not investigate the effect of preference for a particular training approach on such categories of users. While Olfman & Mandviwalla (1994) investigated the issue of training material for their applicability and Carrol & Mazur (1986) investigated the suitability of training materials for the amount of information provided, this study investigated the effect of prior knowledge and experience on training preferences and found this even though it was not significant independently. This is a new finding and a key difference from other studies.

According to Olfman & Mandviwalla (1995), the success of exploration style training is dependent on the reasoning process needed to execute tasks. Another study provides support for the superiority of exploration training over instruction training for meaningful learning (Carrol & Rosson, 1995). According to Assimilation Theory, for meaningful learning to occur, individuals must search long-term memory to retrieve appropriate anchoring ideas or contexts. But studies conducted by Gentner & Gentner (1983), Gick & Holyoak (1983) and Davis & Bostrom (1993) suggest that unless learners are provided with cues to help them retrieve the appropriate ideas, they will often be unable to do so. This is particularly true of learners, such as beginners, who have no prior experience in a given learning domain. There is support for the above argument in this study. For instance, basic subjects who preferred exploration training have done well in terms of effectiveness. Basic subjects who preferred the instruction approach have performed better in terms of efficiency.

When specific tasks were given to users in a radically different environment such as project management, they appeared to struggle with the reasoning processes. It was noticed while playing back the ScreenCAM files that advanced users appeared to manage the reasoning process better (ascertained from mouse movements, selection of menus etc) than basic users and that this was reflected in effectiveness claiming significance.

The combination of training approach and categories of users in this study rated the training environment to be the same the outcome ease of use (around 3.5). Therefore, it can be concluded that this combination did not find the training environment to be different in obtaining the outcomes. This establishes the fact that the training environment was equally appropriate to subjects. Therefore, the rich conceptual elaborations provided in the exploration training materials did not assist users in this study. This supports research by Olfman & Bostrom (1991) which suggests that rich conceptual elaborations need not always assist users. This was reflected in the ease of use score.

Interaction of Learning Style Preferences with other variables in the study

The results concerning individual differences for this study coincide with the study conducted by Olfman & Mandviwalla (1994). While Bostrom et al. (1990) suggested that learning styles have an influence in information processing abilities, Olfman & Mandviwalla (1995) found that they were not significant. In this study, despite using a tested instrument to extract learning style preferences, the combined effect of training and learning style was not significant. Similarly, the findings of this study in terms of the interaction effect between learning style preferences with other variables, especially training approaches is in agreement with Bohlen & Ferrat (1997) who also established that learning styles have no significant effect on training outcomes.

Conclusion

This study raised four research questions (page 80 and 81 – Chapter 3 – Research Questions section). They were:

1. How do different types of interfaces affect training outcomes?
2. How do different approaches to training affect training outcomes?
3. What is the influence of prior knowledge and experience of users on training outcomes?
4. How do different learning styles affect training outcomes?

In response to the first research question, this study has been able to assert that icon interfaces are the most efficient interfaces in terms of efficient and effective training outcomes. There is no evidence to suggest that either of the interfaces are superior in terms of ease of use.

In response to the second research question, this study has been able assert that exploration training is superior in terms of effectiveness and ease of use. None of the training approaches is superior in terms of efficiency.

In response to the third research question, this study has been able to assert that users with basic knowledge and experience are efficient and users with prior knowledge and experience are effective. Both users rated the training environment to be equally easy to use.

In response to the fourth research question, this study has been able to assert that users who have a theorists learning style are efficient and users who have an activists learning style are effective. Users who had an activists learning style found the training environment easy to use.

In addition to this, this study has been able to assert that the interaction combination of menu interfaces and exploration training promotes efficiency and the interaction combination of icon interfaces and exploration training promotes effectiveness. Similarly, for the interaction combination of training approach and category, the basic users who prefer an instruction training approach are more efficient and basic users who prefer an exploration training approach are more effective.

Therefore, this study has been able to conclude that icon interfaces are most suitable to train end users. When users are trained in novel tasks, an exploration approach is most suitable. When users need to be trained in limited time, those with a theorist learning style will benefit the most. When users need to score better as a result of training, an activist learning style will respond better. This study has also been able to conclude that the combination of menu interfaces and exploration training is suitable under tight time constraints for training. Similarly, this study has been able to conclude that when training basic users, either training approaches yield superior results in terms of scores.

The next chapter will discuss the limitations of this study and future research directions.

CHAPTER 6 – LIMITATATIONS AND FUTURE RESEARCH

Previous chapter of this thesis provided discussion on the data analysis performed and concluded the results of the data analysis. This chapter will list the limitation of this study. Following the limitation, directions for future research is provided in this chapter.

Limitations

The limitations of this study can be classified into two categories: instrument limitation and process limitation. Five instruments were used in this study to extract various details of subjects. These instruments were either used from previous studies or modified to suit this study. Despite the statistical tests performed to ensure the validity of these instruments, it is difficult to establish the accuracy of information provided by subjects via these instruments.

One issue that needs to be avoided in future studies is the procedure of 'averaging' opinions expressed to various elements in these instruments to arrive at a measure. For instance, in the first instrument, subjects answered to 12 items ranging from their computing knowledge to project management knowledge. Despite the correlations and applicability of questionnaire items, the average score may not exactly reveal the knowledge of a subject in a particular component, for example, project management. This appears to be a problem in majority of the studies reviewed and no practical solutions were found yet. This is a limitation with the instruments used in this study.

The second limitation of the study is the instrument used to determine learning style preferences. This study used Honey & Mumford (1992) instrument to categorise subjects into one of the four learning styles. While the questionnaire is validated in terms of statistical terms, due to the limited number of subjects in each of the learning styles, the results of this study for this interaction variable cannot be considered conclusive. Due to the classifications, it may so happen that the combined interaction effect of interface style, training type, categories and learning style preference may yield fewer than 4 subjects and this sample size is not acceptable in statistical terms for hypothesis testing. To alleviate any potential problems due to sample sizes, alternative statistical tests applicable to small sample sizes need to be conducted. This may be a limitation. Therefore, there is a need to replicate this research for the learning style variable with a bigger sample.

In this study, training materials were prepared by the author and peer reviewed for appropriateness and applicability. The examples were derived from a book published by Microsoft. Despite the efforts taken to ensure that the materials are appropriate and suitable, rigorous procedures of instructional design were not applied in the preparation of training materials. While this study followed the guidelines given by Dick & Carey (1990) in the overall training design, the instruction-materials and the exploration-materials did not undergo rigorous quality checking usually followed in the domain of instructional design. Any future research should incorporate rigorous quality control procedures in training design and training materials in order to alleviate any bias introduced by individual researchers.

The study process was operationally limited due to a number of factors such as the time duration. In this study, subjects were provided with limited time for training and subsequent hands-on tasks experiment. While previous studies have used a time limit of 30-minutes to 8-hours, there are no guidelines available as to the right amount of time needed to study the effects of hands-on tasks. Based on the suggestions provided by Davies et al. (1989), Sein & Bostrom (1989) and Davis & Bostrom (1993), this study used a 45-minute period for training and experiment respectively. While replaying the ScreenCAM files, it was noted that when subjects crossed the 30-minute period, they were tired and the speed of operations slowed down. In fact, 2 subjects discontinued the experiment as result of exhaustion. The allocation of time appears to be a major limitation. Perhaps, this could be overcome by having multiple sessions of 30 minutes each.

Another operational limitation was the time slot allocated for the booking of computer laboratories in the University where the study was conducted. The computer laboratories can be booked only for a 2-hour block and subjects felt this time was not sufficient for training for a radically new concept such as Microsoft Project. Further certain aspects such as satisfaction and ease of use were measured after one week from the completion of the experiment due to this constraint. This time delay would have impacted in subjects forgetting some specific issues associated with the ease of use and satisfaction. This is seen as a limitation and future studies should allocate more time for training, experiment and immediate measurement.

The next operational difficulty stems from the fact that categories of subjects were determined in this study based on an instrument and not on hands-on examination. Despite the responses to the first two questionnaires to extract knowledge and experience, which was used to determine the subject categories basic and advanced, this study was not able to verify whether these questionnaires actually reflected the two levels. There are no uniform guidelines available to distinguish subjects into these two categories and only recently the Australian Government started introducing competency standard to categorise subjects into different levels. This limitation is even encountered by education institutions.

This study captured users' responses for ease of use and satisfaction after about a week and this can be considered as a limitation because users' could have forgotten some critical aspects of the application provided.

This study recorded the subjects' responses using two independent research assistants. Despite file comparison methods employed to remove any errors, this study will not be able to guarantee an error free recording of subjects' responses. If an automated tool were used, perhaps some of the errors could have been minimised. While a number of automated tools such as 'key log' programs were considered for this study, none of them were implemented because these tools were not capturing various actions of users while accomplishing tasks. Therefore, it should be assumed that errors could have penetrated and hence the results of this study should be interpreted accordingly. Future studies should consider the use of automated tools in order to avoid any manual errors.

Another limitation of the study was the use of preferred training approach during hands-on experiment by subjects. Despite the fact that subjects have opted for either instruction training or exploration training, this study was not able to track whether subjects actually applied the preferred training-approach at hands-on tasks time. The ScreenCAM only captured keystrokes and not training approaches. It appears that there is no automated instrument available to track the application of a given training approach. Therefore, future studies should ascertain that subjects have used their preferred approach in the experiment to avoid any compounding effects that can be introduced by the training approaches.

Directions for Future Research

This study compared two interface types, two training approaches and two categories of users on training outcomes. In many respects, this study was a first attempt to ask questions that, up to this point, have not bee asked. This is especially true of the combination of categories of users and interfaces. The study has resulted in two important benefits. First, it provides information on the nature and extent of the influence of these factors on short computer training programmes. Second it raises a number of important issues for future research.

This study evaluated the impact of training at only one point in time, namely, immediately after the training. Only a few reported studies have examined the effects of training methods over longer periods (Carrol & Mazur, 1986; Olfman, 1987; Sein et al., 1993). None, however, have examined the long-term learning effects of the interface in a training environment. One way to test the effects of interfaces on training outcomes is to examine the effects after a certain time period such as one month after training. Another approach could be to use longitudinal studies to observe how individuals' use and perceptions of the training environment change over time.

Another issue deals with the experience of users. As users learn applications, their knowledge and experience grow. It is interesting to find out how their perceptions change in accordance with the gained knowledge and experience. Further, there is a concept that learning style preferences change during the course of learning. It is difficult to determine these changes in short training programs. However, when longitudinal impacts are studied, it may be possible to study the changing nature of learning styles. This information may provide some valuable information in EUC training.

The third issue relates to more detailed analysis of training approaches. The training approaches used in this study were operationalised using the guidelines provided by the literature. There is no way of knowing whether these approaches were implemented in the best possible way. Therefore, there is a necessity to explore best practices in implementing these training approaches. This may include how to write better and effective training manuals. For example, it may be better to know whether counter-examples have any effects on learning. Further, as mentioned in the limitations section, use of automated tools to track the use of training approaches will bring out new knowledge about how these training approaches are used. This may have an impact on the preparation of training manuals.

This study used only tertiary students involved in a science discipline. Future studies should consider subjects from other areas of study in order to determine the effects of the variables considered in this study on training outcomes. In addition, Honey & Mumford (1992) suggest that learning styles are dependent upon the type of study area such as science, business and engineering. The results of this study should be applied on other disciplines to derive new knowledge.

The results of this study is restricted to input-training-output model. The processes applicable to this study in terms of research methods were verified, but the actual 'learning' processes haven't been verified. There is a need to verify whether there is actually any transfer of knowledge due to training, and if so, how did the transfer occur. This study used ScreenCAM to capture the on-screen movements of mouse strokes and keyboard actions. However, this study did not capture how subjects transferred their mental model into a computer model in order to solve the given tasks. Perhaps, by asking subject what they are thinking as they are accomplishing tasks may bring out new information that is not captured so far. A video camera or a computer camera can be used to capture such details. This approach should lead to a more thorough knowledge of how users conceive of and learn to use computer systems based on the information presented.

Another aspect that needs to be considered in EUC studies is the transition between basic and advanced types. Due to operational difficulties, this study considered only basic and advanced users. However, it appears that there is an 'intermediate' category available as a number of textbooks and training materials have emerged in the past three years with this category. Therefore, it is possible to derive interesting results by considering this category also in EUC research. One complication that researchers may encounter is the uniform definition of these categories. Various computer societies are trying to define levels to determine competency and hopefully these levels can be sorted out soon.

Finally, the questions examined in this study should be extended to different operating systems. It is commonly believed that end users are familiar with either a

PC or MAC system. Recent invasion of Linux and other operating systems have provided new interfaces to users to consider. In addition to the application interfaces, systems are driven by voice-activated interfaces also. A number of new training methods involving multimedia technology have also started appearing in the computing training domain. These new issues have opened up new challenges. Therefore, it is necessary to test other applications and interfaces with new training methods to determine the boundaries of the conclusions presented in this study. The range of new issues represents an extremely challenging, fruitful and interesting line research for those who are inclined to pursue them.

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APPENDIX 1 – SPSS OUTPUT

Descriptive Statistics

	level	interface	training	lstyle	Mean	Std. Deviation	N
efficiency	Basic	icon	Instruct	Activist	36.5096	17.4615	5
				Reflector	35.9744	7.1579	8
				Theorist	31.4273	9.9732	6
				Pragmatist	36.3592	9.4779	7
				Total	35.1316	10.4358	26
			Explore	Activist	32.4199	14.0766	3
				Reflector	36.1608	13.6988	5
				Theorist	34.8817	2.9032	3
				Pragmatist	34.2546	4.3198	2
				Total	34.7091	10.0383	13
			Total	Activist	34.9760	15.3404	8
				Reflector	36.0461	9.6150	13
				Theorist	32.5788	8.2009	9
				Pragmatist	35.8915	8.4004	9
				Total	34.9907	10.1740	39
		menu	Instruct	Activist	37.1986	11.3119	10
				Reflector	33.9657	4.5780	6
				Theorist	31.6338	12.9319	7
				Pragmatist	39.5761	16.2045	8
				Total	35.9299	12.0730	31
			Explore	Activist	52.2267	4.6010	4
				Reflector	43.2474	7.5698	2
				Theorist	39.5603	11.2384	7
				Total	44.0249	10.3619	13
			Total	Activist	41.4923	11.9628	14
				Reflector	36.2861	6.4511	8
				Theorist	35.5971	12.3448	14
				Pragmatist	39.5761	16.2045	8
				Total	38.3216	12.0670	44
		Total	Instruct	Activist	36.9690	13.0188	15
				Reflector	35.1135	6.0592	14
				Theorist	31.5385	11.1836	13
				Pragmatist	38.0749	13.1359	15
				Total	35.5657	11.2634	57
			Explore	Activist	43.7380	13.7376	7
				Reflector	38.1855	12.1083	7
				Theorist	38.1568	9.5489	10
				Pragmatist	34.2546	4.3198	2
				Total	39.3670	11.0666	26
			Total	Activist	39.1228	13.3164	22
				Reflector	36.1375	8.3696	21
				Theorist	34.4160	10.8063	23
				Pragmatist	37.6254	12.3999	17
				Total	36.7565	11.2749	83
	Advance	icon	Instruct	Activist	28.8000	.	1
				Reflector	47.1920	18.5830	3
				Theorist	41.8347	23.0357	6

				Pragmatist	38.4951	24.3667	5
				Total	40.9240	20.7333	15
			Explore	Activist	40.0123	11.4710	9
				Reflector	40.5251	10.1514	8
				Theorist	39.4027	19.4378	6
				Pragmatist	26.4970	11.5611	4
				Total	38.0265	13.4345	27
			Total	Activist	38.8910	11.3813	10
				Reflector	42.3433	12.2841	11
				Theorist	40.6187	20.3606	12
				Pragmatist	33.1626	19.6718	9
				Total	39.0613	16.2239	42
		menu	Instruct	Activist	48.3619	24.1771	3
				Reflector	44.4567	14.2094	10
				Theorist	39.6000	.	1
				Pragmatist	47.9161	14.8957	3
				Total	45.4706	14.8276	17
			Explore	Activist	28.7614	3.6729	3
				Reflector	48.4067	17.3558	6
				Theorist	34.5522	19.0026	3
				Pragmatist	42.1029	18.1834	5
				Total	40.6409	16.7424	17
			Total	Activist	38.5617	18.8272	6
				Reflector	45.9379	15.0151	16
				Theorist	35.8142	15.7195	4
				Pragmatist	44.2828	16.1673	8
				Total	43.0558	15.7643	34
		Total	Instruct	Activist	43.4714	22.0307	4
				Reflector	45.0879	14.5059	13
				Theorist	41.5155	21.0456	7
				Pragmatist	42.0280	20.6506	8
				Total	43.3394	17.6896	32
			Explore	Activist	37.1995	11.1374	12
				Reflector	43.9029	13.7014	14
				Theorist	37.7858	18.2291	9
				Pragmatist	35.1669	16.8253	9
				Total	39.0366	14.6660	44
			Total	Activist	38.7675	13.9965	16
				Reflector	44.4735	13.8328	27
				Theorist	39.4176	18.9221	16
				Pragmatist	38.3956	18.4547	17
				Total	40.8483	16.0385	76
	Total	icon	Instruct	Activist	35.2247	15.9321	6
				Reflector	39.0337	11.5059	11
				Theorist	36.6310	17.7751	12
				Pragmatist	37.2492	16.3130	12
				Total	37.2508	15.0499	41
			Explore	Activist	38.1142	11.9798	12
				Reflector	38.8465	11.2938	13
				Theorist	37.8957	15.6000	9
				Pragmatist	29.0828	9.9988	6
				Total	36.9483	12.4019	40
			Total	Activist	37.1510	13.0186	18
				Reflector	38.9323	11.1407	24
				Theorist	37.1730	16.4781	21
				Pragmatist	34.5271	14.7406	18
				Total	37.1014	13.7205	81
		menu	Instruct	Activist	39.7748	14.7430	13

				Reflector	40.5226	12.4757	16
				Theorist	32.6296	12.2994	8
				Pragmatist	41.8506	15.6001	11
				Total	39.3089	13.7530	48
			Explore	Activist	42.1701	13.1301	7
				Reflector	47.1169	15.1344	8
				Theorist	38.0579	13.0498	10
				Pragmatist	42.1029	18.1834	5
				Total	42.1073	14.2124	30
			Total	Activist	40.6131	13.8958	20
				Reflector	42.7207	13.4648	24
				Theorist	35.6453	12.6551	18
				Pragmatist	41.9295	15.8248	16
				Total	40.3852	13.9070	78
		Total	Instruct	Activist	38.3379	14.8369	19
				Reflector	39.9160	11.8856	27
				Theorist	35.0304	15.5788	20
				Pragmatist	39.4499	15.7860	23
				Total	38.3608	14.3192	89
			Explore	Activist	39.6085	12.2152	19
				Reflector	41.9971	13.1770	21
				Theorist	37.9811	13.9038	19
				Pragmatist	35.0010	15.1154	11
				Total	39.1593	13.3582	70
			Total	Activist	38.9732	13.4200	38
				Reflector	40.8265	12.3743	48
				Theorist	36.4679	14.6681	39
				Pragmatist	38.0105	15.4865	34
				Total	38.7123	13.8667	159
effectiveness	Basic	Icon	Instruct	Activist	53.6000	7.1972	5
				Reflector	55.8750	16.8645	8
				Theorist	44.6667	15.0953	6
				Pragmatist	50.1429	23.6885	7
				Total	51.3077	16.9370	26
			Explore	Activist	61.6667	10.5987	3
				Reflector	73.8000	17.3118	5
				Theorist	55.6667	12.4231	3
				Pragmatist	47.5000	7.7782	2
				Total	62.7692	15.8701	13
			Total	Activist	56.6250	8.8952	8
				Reflector	62.7692	18.6599	13
				Theorist	48.3333	14.5344	9
				Pragmatist	49.5556	20.7311	9
				Total	55.1282	17.2690	39
		menu	Instruct	Activist	32.3000	13.8728	10
				Reflector	33.0000	11.6619	6
				Theorist	37.2857	13.5365	7
				Pragmatist	30.5000	8.0534	8
				Total	33.0968	11.7597	31
			Explore	Activist	50.5000	12.0692	4
				Reflector	36.5000	7.7782	2
				Theorist	37.1429	9.6855	7
				Total	41.1538	11.4225	13
			Total	Activist	37.5000	15.4808	14
				Reflector	33.8750	10.4120	8
				Theorist	37.2143	11.3081	14
				Pragmatist	30.5000	8.0534	8
				Total	35.4773	12.1128	44

		Total	Instruct	Activist	39.4000	15.7017	15
				Reflector	46.0714	18.5326	14
				Theorist	40.6923	14.1856	13
				Pragmatist	39.6667	19.3858	15
				Total	41.4035	16.9082	57
			Explore	Activist	55.2857	12.0791	7
				Reflector	63.1429	23.2625	7
				Theorist	42.7000	13.3004	10
				Pragmatist	47.5000	7.7782	2
				Total	51.9615	17.4642	26
			Total	Activist	44.4545	16.2297	22
				Reflector	51.7619	21.2977	21
				Theorist	41.5652	13.5339	23
				Pragmatist	40.5882	18.4223	17
				Total	44.7108	17.6777	83
	Advance	icon	Instruct	Activist	85.0000	.	1
				Reflector	66.0000	14.9332	3
				Theorist	59.5000	23.1495	6
				Pragmatist	46.2000	23.6474	5
				Total	58.0667	22.3494	15
			Explore	Activist	55.7778	14.7036	9
				Reflector	48.0000	18.1344	8
				Theorist	43.8333	17.4289	6
				Pragmatist	48.2500	10.8743	4
				Total	49.7037	15.7817	27
			Total	Activist	58.7000	16.6603	10
				Reflector	52.9091	18.5874	11
				Theorist	51.6667	21.1803	12
				Pragmatist	47.1111	18.0308	9
				Total	52.6905	18.5728	42
		menu	Instruct	Activist	43.0000	3.4641	3
				Reflector	38.0000	9.2496	10
				Theorist	41.0000	.	1
				Pragmatist	47.0000	2.0000	3
				Total	40.6471	7.9447	17
			Explore	Activist	41.6667	7.7675	3
				Reflector	39.6667	6.7725	6
				Theorist	50.3333	10.0664	3
				Pragmatist	35.0000	11.0227	5
				Total	40.5294	9.6444	17
			Total	Activist	42.3333	5.4283	6
				Reflector	38.6250	8.2047	16
				Theorist	48.0000	9.4516	4
				Pragmatist	39.5000	10.4471	8
				Total	40.5882	8.7008	34
		Total	Instruct	Activist	53.5000	21.1896	4
				Reflector	44.4615	15.8777	13
				Theorist	56.8571	22.2593	7
				Pragmatist	46.5000	17.9125	8
				Total	48.8125	18.3346	32
			Explore	Activist	52.2500	14.4545	12
				Reflector	44.4286	14.5956	14
				Theorist	46.0000	15.0250	9
				Pragmatist	40.8889	12.4041	9
				Total	46.1591	14.3396	44
			Total	Activist	52.5625	15.5990	16
				Reflector	44.4444	14.9289	27
				Theorist	50.7500	18.6958	16

				Pragmatist	43.5294	15.0213	17
				Total	47.2763	16.0803	76
	Total	icon	Instruct	Activist	58.8333	14.3446	6
				Reflector	58.6364	16.3112	11
				Theorist	52.0833	20.1786	12
				Pragmatist	48.5000	22.6615	12
				Total	53.7805	19.1043	41
			Explore	Activist	57.2500	13.5923	12
				Reflector	57.9231	21.5037	13
				Theorist	47.7778	16.2310	9
				Pragmatist	48.0000	9.1214	6
				Total	53.9500	16.7913	40
			Total	Activist	57.7778	13.4407	18
				Reflector	58.2500	18.8962	24
				Theorist	50.2381	18.2781	21
				Pragmatist	48.3333	18.8898	18
				Total	53.8642	17.8870	81
		menu	Instruct	Activist	34.7692	12.9753	13
				Reflector	36.1250	10.1448	16
				Theorist	37.7500	12.6010	8
				Pragmatist	35.0000	10.2762	11
				Total	35.7708	11.0939	48
			Explore	Activist	46.7143	10.7349	7
				Reflector	38.8750	6.5995	8
				Theorist	41.1000	11.2096	10
				Pragmatist	35.0000	11.0227	5
				Total	40.8000	10.2668	30
			Total	Activist	38.9500	13.3001	20
				Reflector	37.0417	9.0625	24
				Theorist	39.6111	11.6121	18
				Pragmatist	35.0000	10.1390	16
				Total	37.7051	10.9948	78
		Total	Instruct	Activist	42.3684	17.3628	19
				Reflector	45.2963	16.9928	27
				Theorist	46.3500	18.6047	20
				Pragmatist	42.0435	18.7701	23
				Total	44.0674	17.6955	89
			Explore	Activist	53.3684	13.3633	19
				Reflector	50.6667	19.5585	21
				Theorist	44.2632	13.8437	19
				Pragmatist	42.0909	11.6744	11
				Total	48.3143	15.7043	70
			Total	Activist	47.8684	16.2666	38
				Reflector	47.6458	18.1594	48
				Theorist	45.3333	16.2777	39
				Pragmatist	42.0588	16.6186	34
				Total	45.9371	16.9286	159
ease of use	Basic	icon	Instruct	Activist	3.5280	.8686	5
				Reflector	3.2656	.6539	8
				Theorist	2.8458	.9830	6
				Pragmatist	3.4036	.6590	7
				Total	3.2563	.7741	26
			Explore	Activist	3.4283	.7033	3
				Reflector	3.3850	.7237	5
				Theorist	3.4800	.0000	3
				Pragmatist	2.7175	.1520	2
				Total	3.3142	.5749	13
			Total	Activist	3.4906	.7584	8

				Reflector	3.3115	.6539	13
				Theorist	3.0572	.8394	9
				Pragmatist	3.2511	.6482	9
				Total	3.2756	.7067	39
		menu	Instruct	Activist	3.6760	.9622	10
				Reflector	3.4567	.9565	6
				Theorist	4.2664	.6641	7
				Pragmatist	3.5519	.9903	8
				Total	3.7348	.9158	31
			Explore	Activist	3.7900	.8412	4
				Reflector	3.9800	.8627	2
				Theorist	3.8193	.6703	7
				Total	3.8350	.6840	13
			Total	Activist	3.7086	.8984	14
				Reflector	3.5875	.9047	8
				Theorist	4.0429	.6817	14
				Pragmatist	3.5519	.9903	8
				Total	3.7644	.8473	44
		Total	Instruct	Activist	3.6267	.9033	15
				Reflector	3.3475	.7692	14
				Theorist	3.6108	1.0801	13
				Pragmatist	3.4827	.8261	15
				Total	3.5166	.8802	57
			Explore	Activist	3.6350	.7457	7
				Reflector	3.5550	.7467	7
				Theorist	3.7175	.5713	10
				Pragmatist	2.7175	.1520	2
				Total	3.5746	.6736	26
			Total	Activist	3.6293	.8384	22
				Reflector	3.4167	.7496	21
				Theorist	3.6572	.8791	23
				Pragmatist	3.3926	.8143	17
				Total	3.5348	.8174	83
	Advance	icon	Instruct	Activist	4.5850	.	1
				Reflector	3.5617	9.438E-02	3
				Theorist	3.5717	.4993	6
				Pragmatist	2.9290	.7018	5
				Total	3.4230	.6544	15
			Explore	Activist	3.6211	.5659	9
				Reflector	3.3469	.7504	8
				Theorist	3.5067	.6134	6
				Pragmatist	3.8300	.4383	4
				Total	3.5454	.6096	27
			Total	Activist	3.7175	.6145	10
				Reflector	3.4055	.6372	11
				Theorist	3.5392	.5343	12
				Pragmatist	3.3294	.7374	9
				Total	3.5017	.6208	42
		menu	Instruct	Activist	4.0467	.1549	3
				Reflector	3.7090	.3845	10
				Theorist	2.9500	.	1
				Pragmatist	3.2450	.7595	3
				Total	3.6421	.5012	17
			Explore	Activist	3.3933	.7989	3
				Reflector	3.5633	.7238	6
				Theorist	4.1083	.3770	3
				Pragmatist	3.6020	.6170	5
				Total	3.6409	.6416	17

			Total	Activist	3.7200	.6269	6
				Reflector	3.6544	.5183	16
				Theorist	3.8188	.6559	4
				Pragmatist	3.4681	.6453	8
				Total	3.6415	.5669	34
		Total	Instruct	Activist	4.1813	.2974	4
				Reflector	3.6750	.3414	13
				Theorist	3.4829	.5128	7
				Pragmatist	3.0475	.6877	8
				Total	3.5394	.5791	32
			Explore	Activist	3.5642	.5997	12
				Reflector	3.4396	.7191	14
				Theorist	3.7072	.6010	9
				Pragmatist	3.7033	.5261	9
				Total	3.5823	.6165	44
			Total	Activist	3.7184	.5980	16
				Reflector	3.5530	.5716	27
				Theorist	3.6091	.5577	16
				Pragmatist	3.3947	.6776	17
				Total	3.5642	.5975	76
	Total	icon	Instruct	Activist	3.7042	.8887	6
				Reflector	3.3464	.5658	11
				Theorist	3.2087	.8344	12
				Pragmatist	3.2058	.6897	12
				Total	3.3173	.7287	41
			Explore	Activist	3.5729	.5749	12
				Reflector	3.3615	.7096	13
				Theorist	3.4978	.4851	9
				Pragmatist	3.4592	.6707	6
				Total	3.4703	.6012	40
			Total	Activist	3.6167	.6710	18
				Reflector	3.3546	.6340	24
				Theorist	3.3326	.7061	21
				Pragmatist	3.2903	.6747	18
				Total	3.3928	.6691	81
		menu	Instruct	Activist	3.7615	.8513	13
				Reflector	3.6144	.6400	16
				Theorist	4.1019	.7712	8
				Pragmatist	3.4682	.9069	11
				Total	3.7020	.7892	48
			Explore	Activist	3.6200	.7820	7
				Reflector	3.6675	.7195	8
				Theorist	3.9060	.5921	10
				Pragmatist	3.6020	.6170	5
				Total	3.7250	.6560	30
			Total	Activist	3.7120	.8097	20
				Reflector	3.6321	.6522	24
				Theorist	3.9931	.6637	18
				Pragmatist	3.5100	.8086	16
				Total	3.7108	.7365	78
		Total	Instruct	Activist	3.7434	.8386	19
				Reflector	3.5052	.6144	27
				Theorist	3.5660	.9076	20
				Pragmatist	3.3313	.7935	23
				Total	3.5248	.7818	89
			Explore	Activist	3.5903	.6375	19
				Reflector	3.4781	.7117	21
				Theorist	3.7126	.5690	19

				Pragmatist	3.5241	.6187	11
				Total	3.5794	.6335	70
			Total	Activist	3.6668	.7388	38
				Reflector	3.4933	.6515	48
				Theorist	3.6374	.7555	39
				Pragmatist	3.3937	.7376	34
				Total	3.5488	.7186	159

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.970	1381.687	3.000	126.000	.000
	Wilks' Lambda	.030	1381.687	3.000	126.000	.000
	Hotelling's Trace	32.897	1381.687	3.000	126.000	.000
	Roy's Largest Root	32.897	1381.687	3.000	126.000	.000
LEVEL	Pillai's Trace	.025	1.057	3.000	126.000	.370
	Wilks' Lambda	.975	1.057	3.000	126.000	.370
	Hotelling's Trace	.025	1.057	3.000	126.000	.370
	Roy's Largest Root	.025	1.057	3.000	126.000	.370
INTERFAC	Pillai's Trace	.274	15.846	3.000	126.000	.000
	Wilks' Lambda	.726	15.846	3.000	126.000	.000
	Hotelling's Trace	.377	15.846	3.000	126.000	.000
	Roy's Largest Root	.377	15.846	3.000	126.000	.000
TRAINING	Pillai's Trace	.002	.064	3.000	126.000	.979
	Wilks' Lambda	.998	.064	3.000	126.000	.979
	Hotelling's Trace	.002	.064	3.000	126.000	.979
	Roy's Largest Root	.002	.064	3.000	126.000	.979
LSTYL	Pillai's Trace	.106	1.567	9.000	384.000	.123
	Wilks' Lambda	.895	1.587	9.000	306.801	.118
	Hotelling's Trace	.115	1.599	9.000	374.000	.114
	Roy's Largest Root	.099	4.210	3.000	128.000	.007
LEVEL * INTERFAC	Pillai's Trace	.035	1.529	3.000	126.000	.210
	Wilks' Lambda	.965	1.529	3.000	126.000	.210
	Hotelling's Trace	.036	1.529	3.000	126.000	.210
	Roy's Largest Root	.036	1.529	3.000	126.000	.210
LEVEL *	Pillai's	.053	2.335	3.000	126.000	.077

TRAINING	Trace					
	Wilks' Lambda	.947	2.335	3.000	126.000	.077
	Hotelling's Trace	.056	2.335	3.000	126.000	.077
	Roy's Largest Root	.056	2.335	3.000	126.000	.077
INTERFAC * TRAINING	Pillai's Trace	.006	.235	3.000	126.000	.872
	Wilks' Lambda	.994	.235	3.000	126.000	.872
	Hotelling's Trace	.006	.235	3.000	126.000	.872
	Roy's Largest Root	.006	.235	3.000	126.000	.872
LEVEL * INTERFAC * TRAINING	Pillai's Trace	.066	2.958	3.000	126.000	.035
	Wilks' Lambda	.934	2.958	3.000	126.000	.035
	Hotelling's Trace	.070	2.958	3.000	126.000	.035
	Roy's Largest Root	.070	2.958	3.000	126.000	.035
LEVEL * LSTYL	Pillai's Trace	.052	.746	9.000	384.000	.666
	Wilks' Lambda	.949	.746	9.000	306.801	.666
	Hotelling's Trace	.054	.746	9.000	374.000	.667
	Roy's Largest Root	.048	2.060	3.000	128.000	.109
INTERFAC * LSTYL	Pillai's Trace	.077	1.124	9.000	384.000	.344
	Wilks' Lambda	.924	1.118	9.000	306.801	.349
	Hotelling's Trace	.080	1.110	9.000	374.000	.355
	Roy's Largest Root	.049	2.101	3.000	128.000	.103
LEVEL * INTERFAC * LSTYL	Pillai's Trace	.063	.914	9.000	384.000	.513
	Wilks' Lambda	.938	.915	9.000	306.801	.512
	Hotelling's Trace	.066	.916	9.000	374.000	.511
	Roy's Largest Root	.058	2.476	3.000	128.000	.064
TRAINING * LSTYL	Pillai's Trace	.035	.499	9.000	384.000	.875

	Wilks' Lambda	.966	.495	9.000	306.801	.876
	Hotelling's Trace	.035	.491	9.000	374.000	.881
	Roy's Largest Root	.026	1.115	3.000	128.000	.346
LEVEL * TRAINING * LSTYL	Pillai's Trace	.103	1.510	9.000	384.000	.142
	Wilks' Lambda	.898	1.546	9.000	306.801	.131
	Hotelling's Trace	.114	1.576	9.000	374.000	.121
	Roy's Largest Root	.112	4.764	3.000	128.000	.004
INTERFAC * TRAINING * LSTYL	Pillai's Trace	.065	.950	9.000	384.000	.482
	Wilks' Lambda	.935	.954	9.000	306.801	.479
	Hotelling's Trace	.069	.956	9.000	374.000	.476
	Roy's Largest Root	.063	2.673	3.000	128.000	.050
LEVEL * INTERFAC * TRAINING * LSTYL	Pillai's Trace	.053	1.156	6.000	254.000	.331
	Wilks' Lambda	.948	1.147	6.000	252.000	.336
	Hotelling's Trace	.055	1.138	6.000	250.000	.341
	Roy's Largest Root	.029	1.239	3.000	127.000	.298

a Exact statistic
b The statistic is an upper bound on F that yields a lower bound on the significance level.
c Design: Intercept+LEVEL+INTERFAC+TRAINING+LSTYL+LEVEL * INTERFAC+LEVEL * TRAINING+INTERFAC * TRAINING+LEVEL * INTERFAC * TRAINING+LEVEL * LSTYL+INTERFAC * LSTYL+LEVEL * INTERFAC * LSTYL+TRAINING * LSTYL+LEVEL * TRAINING * LSTYL+INTERFAC * TRAINING * LSTYL+LEVEL * INTERFAC * TRAINING * LSTYL

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	efficiency	4816.531	30	160.551	.804	.752
	effectiveness	18648.481	30	621.616	2.988	.000
	ease of use	16.626	30	.554	1.092	.357
Intercept	efficiency	160774.602	1	160774.602	804.994	.000

	effectiveness	239068.284	1	239068.284	1149.069	.000
	ease of use	1340.100	1	1340.100	2640.264	.000
LEVEL	efficiency	79.064	1	79.064	.396	.530
	effectiveness	493.795	1	493.795	2.373	.126
	ease of use	.374	1	.374	.738	.392
INTERFAC	efficiency	701.271	1	701.271	3.511	.063
	effectiveness	8484.064	1	8484.064	40.778	.000
	ease of use	.768	1	.768	1.514	.221
TRAINING	efficiency	1.014	1	1.014	.005	.943
	effectiveness	38.469	1	38.469	.185	.668
	ease of use	2.274E-05	1	2.274E-05	.000	.995
LSTYL	efficiency	363.969	3	121.323	.607	.611
	effectiveness	1848.182	3	616.061	2.961	.035
	ease of use	2.446	3	.815	1.606	.191
LEVEL * INTERFAC	efficiency	75.637	1	75.637	.379	.539
	effectiveness	410.026	1	410.026	1.971	.163
	ease of use	.992	1	.992	1.954	.165
LEVEL * TRAINING	efficiency	589.056	1	589.056	2.949	.088
	effectiveness	860.844	1	860.844	4.138	.044
	ease of use	8.241E-02	1	8.241E-02	.162	.688
INTERFAC * TRAINING	efficiency	95.214	1	95.214	.477	.491
	effectiveness	55.891	1	55.891	.269	.605
	ease of use	5.171E-06	1	5.171E-06	.000	.997
LEVEL * INTERFAC * TRAINING	efficiency	450.920	1	450.920	2.258	.135
	effectiveness	1133.539	1	1133.539	5.448	.021
	ease of use	.625	1	.625	1.232	.269
LEVEL * LSTYL	efficiency	632.696	3	210.899	1.056	.370
	effectiveness	497.707	3	165.902	.797	.497
	ease of use	.573	3	.191	.376	.770
INTERFAC * LSTYL	efficiency	705.268	3	235.089	1.177	.321
	effectiveness	937.580	3	312.527	1.502	.217
	ease of use	1.099	3	.366	.722	.541
LEVEL * INTERFAC * LSTYL	efficiency	49.283	3	16.428	.082	.970
	effectiveness	1275.877	3	425.292	2.044	.111
	ease of use	1.289	3	.430	.846	.471
TRAINING * LSTYL	efficiency	38.509	3	12.836	.064	.979
	effectiveness	237.670	3	79.223	.381	.767
	ease of use	1.675	3	.558	1.100	.352
LEVEL * TRAINING * LSTYL	efficiency	102.028	3	34.009	.170	.916
	effectiveness	1210.253	3	403.418	1.939	.127
	ease of use	4.552	3	1.517	2.990	.034
INTERFAC * TRAINING * LSTYL	efficiency	319.815	3	106.605	.534	.660
	effectiveness	1160.908	3	386.969	1.860	.140

	ease of use	.882	3	.294	.579	.630
LEVEL * INTERFAC * TRAINING * LSTYL	efficiency	642.994	2	321.497	1.610	.204
	effectiveness	81.419	2	40.709	.196	.823
	ease of use	1.788	2	.894	1.761	.176
Error	efficiency	25564.354	128	199.722		
	effectiveness	26630.890	128	208.054		
	ease of use	64.968	128	.508		
Total	efficiency	268665.308	159			
	effectiveness	380804.000	159			
	ease of use	2084.078	159			
Corrected Total	efficiency	30380.885	158			
	effectiveness	45279.371	158			
	ease of use	81.594	158			

a R Squared = .159 (Adjusted R Squared = -.039)
b R Squared = .412 (Adjusted R Squared = .274)
c R Squared = .204 (Adjusted R Squared = .017)

Descriptive Statistics for the variable interface

		Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
interface		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
icon	efficiency	65.02	11.78	76.80	37.1014	1.5245	13.7205	188.253	.422	.267	.147	.529
	effectiveness	78.00	15.00	93.00	53.8642	1.9874	17.8870	319.944	.089	.267	-.465	.529
	ease of use	3.70	1.31	5.00	3.3928	7.434E-02	.6691	.448	-.433	.267	.374	.529
	Valid N (listwise)											
menu	efficiency	59.16	17.16	76.32	40.3852	1.5747	13.9070	193.405	.669	.272	-.182	.538
	effectiveness	53.00	11.00	64.00	37.7051	1.2449	10.9948	120.886	-.271	.272	.164	.538
	ease of use	3.22	1.74	4.96	3.7108	8.339E-02	.7365	.542	-.480	.272	-.137	.538

Descriptive Statistics for the variable training approach

		Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
training		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Instruct	efficiency	65.02	11.78	76.80	38.3608	1.5178	14.3192	205.039	.690	.255	.166	.506
	effectiveness	82.00	11.00	93.00	44.0674	1.8757	17.6955	313.132	.598	.255	.091	.506
	ease of use	3.62	1.31	4.93	3.5248	8.287E-02	.7818	.611	-.545	.255	.004	.506
	Valid N (listwise)											
Explore	efficiency	63.29	13.03	76.32	39.1593	1.5966	13.3582	178.441	.315	.287	-.117	.566
	effectiveness	78.00	15.00	93.00	48.3143	1.8770	15.7043	246.624	.526	.287	.438	.566
	ease of use	2.53	2.48	5.00	3.5794	7.571E-02	.6335	.401	.165	.287	-.681	.566

Descriptive Statistics for the variable category

		Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
category		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Basic	efficiency	52.70	14.98	67.68	36.7565	1.2376	11.2749	127.123	.370	.264	.031	.523
	effectiveness	82.00	11.00	93.00	44.7108	1.9404	17.6777	312.501	.520	.264	.087	.523
	ease of use	3.66	1.31	4.96	3.5348	8.972E-02	.8174	.668	-.323	.264	-.336	.523
	Valid N (listwise)											
Advance	efficiency	65.02	11.78	76.80	40.8483	1.8397	16.0385	257.234	.388	.276	-.517	.545
	effectiveness	78.00	15.00	93.00	47.2763	1.8445	16.0803	258.576	.576	.276	.281	.545
	ease of use	3.20	1.80	5.00	3.5642	6.854E-02	.5975	.357	-.370	.276	.085	.545

Descriptive Statistics for the variable learning style

		Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
lstyle		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Activist	efficiency	60.22	14.98	75.20	38.9732	2.1770	13.4200	180.096	.286	.383	.063	.750
	effectiveness	74.00	11.00	85.00	47.8684	2.6388	16.2666	264.604	-.042	.383	.545	.750
	ease of use	2.91	2.05	4.96	3.6668	.1199	.7388	.546	-.317	.383	-.490	.750
Reflector	efficiency	52.07	24.25	76.32	40.8265	1.7861	12.3743	153.124	.989	.343	.416	.674
	effectiveness	78.00	15.00	93.00	47.6458	2.6211	18.1594	329.766	.609	.343	.125	.674
	ease of use	3.11	1.90	5.00	3.4933	9.404E-02	.6515	.424	-.047	.343	-.084	.674
Theorist	efficiency	63.77	13.03	76.80	36.4679	2.3488	14.6681	215.152	.571	.378	.097	.741
	effectiveness	78.00	15.00	93.00	45.3333	2.6065	16.2777	264.965	.721	.378	.706	.741
	ease of use	3.62	1.31	4.93	3.6374	.1210	.7555	.571	-.716	.378	1.131	.741
Pragmatist	efficiency	60.22	11.78	72.00	38.0105	2.6559	15.4865	239.830	.601	.403	-.201	.788
	effectiveness	64.00	17.00	81.00	42.0588	2.8501	16.6186	276.178	.758	.403	.041	.788
	ease of use	2.94	1.74	4.68	3.3937	.1265	.7376	.544	-.477	.403	-.307	.788

Descriptive Statistics for interface and training approach combination

			Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
interface	training		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
icon	Instruct	efficiency	65.02	11.78	76.80	37.2508	2.3504	15.0499	226.499	.725	.369	.512	.724
		effectiveness	73.00	20.00	93.00	53.7805	2.9836	19.1043	364.976	.105	.369	-.955	.724
		ease of use	3.28	1.31	4.59	3.3173	.1138	.7287	.531	-.767	.369	.249	.724
	Explore	efficiency	44.57	13.03	57.60	36.9483	1.9609	12.4019	153.806	-.147	.374	-.854	.733
		effectiveness	78.00	15.00	93.00	53.9500	2.6549	16.7913	281.946	.074	.374	.393	.733
		ease of use	2.53	2.48	5.00	3.4703	9.506E-02	.6012	.361	.339	.374	-.371	.733
menu	Instruct	efficiency	58.04	17.16	75.20	39.3089	1.9851	13.7530	189.146	.726	.343	-.054	.674
		effectiveness	48.00	11.00	59.00	35.7708	1.6013	11.0939	123.074	-.560	.343	-.298	.674
		ease of use	3.19	1.74	4.93	3.7020	.1139	.7892	.623	-.603	.343	-.049	.674
	Explore	efficiency	53.01	23.31	76.32	42.1073	2.5948	14.2124	201.991	.622	.427	-.177	.833
		effectiveness	42.00	22.00	64.00	40.8000	1.8745	10.2668	105.407	.411	.427	.007	.833
		ease of use	2.46	2.51	4.96	3.7250	.1198	.6560	.430	-.104	.427	-.709	.833

Descriptive Statistics for interface and category combination

			Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
interface	level		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
icon	Basic	efficiency	45.50	14.98	60.48	34.9907	1.6291	10.1740	103.510	.172	.378	.660	.741
		effectiveness	73.00	20.00	93.00	55.1282	2.7653	17.2690	298.220	.201	.378	-.350	.741
		ease of use	3.10	1.31	4.41	3.2756	.1132	.7067	.499	-.536	.378	.044	.741
	Advance	efficiency	65.02	11.78	76.80	39.0613	2.5034	16.2239	263.214	.240	.365	-.540	.717
		effectiveness	78.00	15.00	93.00	52.6905	2.8659	18.5728	344.951	.038	.365	-.529	.717
		ease of use	3.20	1.80	5.00	3.5017	9.579E-02	.6208	.385	-.189	.365	.589	.717
menu	Basic	efficiency	50.52	17.16	67.68	38.3216	1.8192	12.0670	145.613	.380	.357	-.420	.702
		effectiveness	53.00	11.00	64.00	35.4773	1.8261	12.1128	146.720	.052	.357	.061	.702
		ease of use	3.22	1.74	4.96	3.7644	.1277	.8473	.718	-.547	.357	-.339	.702
	Advance	efficiency	53.01	23.31	76.32	43.0558	2.7036	15.7643	248.514	.661	.403	-.667	.788
		effectiveness	42.00	19.00	61.00	40.5882	1.4922	8.7008	75.704	-.519	.403	.622	.788
		ease of use	2.10	2.42	4.52	3.6415	9.722E-02	.5669	.321	-.617	.403	-.444	.788

Descriptive Statistics for Category and training approach combination

			Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
category	training		Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Basic	Instruct	efficiency	52.70	14.98	67.68	35.5657	1.4919	11.2634	126.864	.507	.316	.468	.623
		effectiveness	70.00	11.00	81.00	41.4035	2.2395	16.9082	285.888	.472	.316	-.106	.623
		ease of use	3.62	1.31	4.93	3.5166	.1166	..8802	.775	-.442	.316	-.476	.623
	Explore	efficiency	43.32	16.49	59.82	39.3670	2.1703	11.0666	122.470	.140	.456	-.403	.887
		effectiveness	69.00	24.00	93.00	51.9615	3.4250	17.4642	304.998	.747	.456	.242	.887
		ease of use	2.43	2.53	4.96	3.5746	.1321	.6736	.454	.454	.456	-.602	.887
Advance	Instruct	efficiency	65.02	11.78	76.80	43.3394	3.1271	17.6896	312.923	.293	.414	-.891	.809
		effectiveness	74.00	19.00	93.00	48.8125	3.2411	18.3346	336.157	.776	.414	.059	.809
		ease of use	2.79	1.80	4.59	3.5394	.1024	.5791	.335	-.975	.414	1.553	.809
	Explore	efficiency	63.29	13.03	76.32	39.0366	2.2110	14.6660	215.091	.366	.357	-.208	.702
		effectiveness	65.00	15.00	80.00	46.1591	2.1618	14.3396	205.625	.145	.357	-.034	.702
		ease of use	2.53	2.48	5.00	3.5823	9.294E-02	.6165	.380	-.038	.357	-.677	.702

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	efficiency	4816.531	30	160.551	.804	.752
	effectiveness	18648.481	30	621.616	2.988	.000
	ease of use	16.626	30	.554	1.092	.357
Intercept	efficiency	160774.602	1	160774.602	804.994	.000
	effectiveness	239068.284	1	239068.284	1149.069	.000
	ease of use	1340.100	1	1340.100	2640.264	.000
LEVEL	efficiency	79.064	1	79.064	.396	.530
	effectiveness	493.795	1	493.795	2.373	.126
	ease of use	.374	1	.374	.738	.392
INTERFAC	efficiency	701.271	1	701.271	3.511	.063
	effectiveness	8484.064	1	8484.064	40.778	.000
	ease of use	.768	1	.768	1.514	.221
TRAINING	efficiency	1.014	1	1.014	.005	.943
	effectiveness	38.469	1	38.469	.185	.668
	ease of use	2.274E-05	1	2.274E-05	.000	.995
LSTYL	efficiency	363.969	3	121.323	.607	.611
	effectiveness	1848.182	3	616.061	2.961	.035
	ease of use	2.446	3	.815	1.606	.191
LEVEL * INTERFAC	efficiency	75.637	1	75.637	.379	.539
	effectiveness	410.026	1	410.026	1.971	.163
	ease of use	.992	1	.992	1.954	.165
LEVEL * TRAINING	efficiency	589.056	1	589.056	2.949	.088
	effectiveness	860.844	1	860.844	4.138	.044
	ease of use	8.241E-02	1	8.241E-02	.162	.688

INTERFAC * TRAINING	efficiency	95.214	1	95.214	.477	.491
	effectiveness	55.891	1	55.891	.269	.605
	ease of use	5.171E-06	1	5.171E-06	.000	.997
LEVEL * INTERFAC * TRAINING	efficiency	450.920	1	450.920	2.258	.135
	effectiveness	1133.539	1	1133.539	5.448	.021
	ease of use	.625	1	.625	1.232	.269
LEVEL * LSTYL	efficiency	632.696	3	210.899	1.056	.370
	effectiveness	497.707	3	165.902	.797	.497
	ease of use	.573	3	.191	.376	.770
INTERFAC * LSTYL	efficiency	705.268	3	235.089	1.177	.321
	effectiveness	937.580	3	312.527	1.502	.217
	ease of use	1.099	3	.366	.722	.541
LEVEL * INTERFAC * LSTYL	efficiency	49.283	3	16.428	.082	.970
	effectiveness	1275.877	3	425.292	2.044	.111
	ease of use	1.289	3	.430	.846	.471
TRAINING * LSTYL	efficiency	38.509	3	12.836	.064	.979
	effectiveness	237.670	3	79.223	.381	.767
	ease of use	1.675	3	.558	1.100	.352
LEVEL * TRAINING * LSTYL	efficiency	102.028	3	34.009	.170	.916
	effectiveness	1210.253	3	403.418	1.939	.127
	ease of use	4.552	3	1.517	2.990	.034
INTERFAC * TRAINING * LSTYL	efficiency	319.815	3	106.605	.534	.660
	effectiveness	1160.908	3	386.969	1.860	.140
	ease of use	.882	3	.294	.579	.630
LEVEL * INTERFAC * TRAINING * LSTYL	efficiency	642.994	2	321.497	1.610	.204
	effectiveness	81.419	2	40.709	.196	.823
	ease of use	1.788	2	.894	1.761	.176
Error	efficiency	25564.354	128	199.722		
	effectiveness	26630.890	128	208.054		
	ease of use	64.968	128	.508		
Total	efficiency	268665.308	159			
	effectiveness	380804.000	159			
	ease of use	2084.078	159			
Corrected Total	efficiency	30380.885	158			
	effectiveness	45279.371	158			
	ease of use	81.594	158			

a R Squared = .159 (Adjusted R Squared = -.039)
b R Squared = .412 (Adjusted R Squared = .274)
c R Squared = .204 (Adjusted R Squared = .017)

APPENDIX 2 – QUESTIONNAIRE 1

Pre-test Questionnaire

Name:

You will be allocated with a unique number for identification purposes during this study. The number will be allocated after assessing your suitability for the study. You will be asked to refer to the number later.

Please fill in the questionnaire by placing a circle on the appropriate number for each item as shown below. Use either a pen or a pencil. Circle only one number per item.

Example:
The following is a set of computer terms. Please circle the appropriate number:

	Know Nothing				Know a lot
1. Cache Memory	1	2	3	4	5
2. SCSI Card	1	2	3	4	5

The following is a set of computer terms. Please circle the appropriate number to indicate your level of familiarity. Circle only one number per item.

	Know Nothing				Know a lot
1. Windows 95	1	2	3	4	5
2. Floppy disk operations	1	2	3	4	5
3. Word-processing applications	1	2	3	4	5
4. Spreadsheet applications	1	2	3	4	5
5. Presentation software applications	1	2	3	4	5
6. Project management applications	1	2	3	4	5
7. Copying files from one area to another	1	2	3	4	5
8. Internet browsers	1	2	3	4	5
9. Installation and use of modems	1	2	3	4	5
10. Customizing application software	1	2	3	4	5
11. e-mail programs	1	2	3	4	5
12. Writing computer programs	1	2	3	4	5
13. Changing print settings	1	2	3	4	5
14. MS Project software application	1	2	3	4	5

Source: Bohlen & Ferrat, 1996; Doll & Xia, 1996

APPENDIX 3 – QUESTIONNAIRE 2

End User Computing Sophistication

End users are defined as the users who use computer systems and application software packages to obtain information without being concerned with the underlying processes and procedures of creating the systems and applications (Capron, 1998). Please indicate your percentage of the following activities performed in end user applications domain on a daily basis by you.

Type of Application

Based upon your experience, indicate the percentage breakdown to which the following end user activities are performed on a daily basis:

Producing standard reports: applications that monitor daily activity producing standard reports on a fixed schedule

_________ %

Processing non standard reports: Exception: applications that process detail activity reports where the definition of exception conditions is fixed (e.g. budget variances)

_________ %

Performing various queries: applications that provide a database with flexible inquiry capability, enabling users to design and change their own monitoring and exception reports

_________ %

Performing analysis on available data: applications that provide powerful data analysis capabilities (modeling, simulation etc) and the appropriate database to support user's decision making

_________ %

TOTAL 100

%

Mode of operation

Indicate among the following statements those which apply to your use of end user applications. Please place a ✓ or a × in the box provided.

- ☐ I use printed reports generated by a central computer
- ☐ I use a stand-alone PC
- ☐ I use a PC linked to a local area network
- ☐ I use a PC with to the Internet
- ☐ I use a PC linked to the central computer

Usage Intensity

On an average working day that you use a computer, how much time do you spend on the system?

- ☐ Almost never
- ☐ Less ½ hour
- ☐ From ½ hour to 1 hour
- ☐ 1 - 2 hours
- ☐ 2 - 3 hours

- ☐ More than 3 hours

On the average, how frequently do you use a computer?

- ☐ Less than once a month
- ☐ Once a month
- ☐ A few times a month
- ☐ A few times a week
- ☐ About once a day
- ☐ Several times a day

Usage purposes

In regard to the requirements of your task, indicate the extent to which you use a computer to accomplish the following activities:

	No extent				Large extent
1. Transfer information to others	1	2	3	4	5
2. Extract data	1	2	3	4	5
3. Analyze trends	1	2	3	4	5
4. Analyze problems or alternatives	1	2	3	4	5
5. Planning	1	2	3	4	5
6. Budgeting	1	2	3	4	5
7. Controlling and guiding activities	1	2	3	4	5
8. Decision making	1	2	3	4	5
9. Produce letters and memos	1	2	3	4	5
10. Other(s) ____________	1	2	3	4	5

Source: Alloway and Quillard, 1983; Igbaria, 1990

APPENDIX 4 – QUESTIONNAIRE 3

THE LEARNING STYLES QUESTIONNAIRE

This questionnaire is to find out your preferred learning style(s). There is no time limit to fill in this questionnaire. It will probably take you about 15 minutes to fill in the questionnaire. There are no right or wrong answers. The accuracy of the answers depends on your preferences.

If you agree with a statement, then place a ✓. If you disagree, then place a ×. Be sure to mark each item. Please mark items in the list ~~provided.~~

1	I have strong beliefs about what is right and wrong, good and bad.	
2	I often 'throw caution to the winds'.	
3	I tend to solve problems using a step-by-step approach, avoiding any 'flights-of-fancy'.	
4	I believe that formal procedures and policies cramp people's style.	
5	I have a reputation for having a no-nonsense, 'call a spade a spade' Style.	
6	I often find that actions based on 'gut feel' are as sound as those based on careful thought and analysis.	
7	I like to do the sort of work where I have time to 'leave no stone unturned'.	
8	I regularly question people about their basic assumptions.	
9	What matters most is whether something works in practice.	
10	I actively seek out new experiences.	
1 1	When I hear about a new idea or approach I immediately start working out how to apply it in practice.	
1 2	I am keen on self-discipline such as watching my diet, taking regular exercise, sticking to a fixed routine, etc.	
13	I take pride in doing a thorough job.	
1 4	I get on best with logical, analytical people and less well with spontaneous, 'irrational' people.	
1 5	I take care over the interpretation of data available to me and avoid jumping to conclusions.	
16	I like to reach a decision carefully after weighing up many alternatives.	
17	I'm attracted more to novel, unusual ideas than to practical ones.	
18	I don't like 'loose-ends' and prefer to fit things into a coherent pattern.	
1 9	I accept and stick to laid down procedures and policies so long as I regard them as an efficient way of getting the job done.	
20	I like to relate my actions to a general principle.	

21	In discussions I like to get straight to the point.	
22	I tend to have distant, rather formal relationships with people at work.	
23	I thrive on the challenge of tackling something new and different.	
24	I enjoy fun-loving, spontaneous people.	
25	I pay meticulous attention to detail before coming to a conclusion.	
26	I find it difficult to come up with wild, off-the-top-of-the-head ideas.	
27	I don't believe in wasting time by 'beating around the bush'.	
28	I am careful not to jump to conclusions too quickly.	
29	I prefer to have as many sources of information as possible – the more data to mull over the better.	
30	Flippant people who don't take things seriously enough usually irritate me.	
31	I listen to other people's point of view before putting my own forward.	
32	I tend to be open about how I'm feeling.	
33	In discussions I enjoy watching the manoeuvering of the other participants.	
34	I prefer to respond to events on a spontaneous, flexible basis rather than plan things out in advance.	
35	I tend to be attracted to techniques such as network analysis, flow charts, branching programmes, contingency planning, etc.	
36	It worries me if I have to rush out a piece of work to meet a tight deadline.	
37	I tend to judge people's ideas on their practical merits.	
38	Quiet, thoughtful people tend to make me feel uneasy.	
39	I often get irritated by people who want to rush headlong into things.	
40	It is more important to enjoy the present moment than to think about the past or future.	
41	I think that decisions based on a thorough analysis of all the information are sounder than those based on intuition.	
42	I tend to be a perfectionist.	
43	In discussions I usually pitch in with lots of off-the-top-of-the-head ideas.	
44	In meetings I put forward practical realistic ideas.	
45	More often than not, rules are there to be broken.	
46	I prefer to stand back from a situation and consider all the perspectives.	
47	I can often see inconsistencies and weaknesses in other people's arguments.	
48	On balance, I talk more than I listen.	
49	I can often see better, more practical ways to get things done.	
50	I think written reports should be short, punchy and to the point.	
51	I believe that rational, logical thinking should win the day.	
52	I tend to discuss specific things with people rather than engaging in 'small talk'.	
53	I like people who have both feet firmly on the ground.	
54	In discussions I get impatient with irrelevancies and 'red herrings'.	
55	If I have a report to write I tend to produce lost of drafts before settling on the final version.	
56	I am keen to try things out to see if they work in practice.	
57	I am keen to reach answers via a logical approach.	
58	I enjoy being the one that talks a lot.	
59	In discussions I often find I am the realist, keeping people to the point and avoiding 'cloud nine' speculations.	
60	I like to ponder many alternatives before making up my mind.	
61	In discussions with people I often find I am the most dispassionate and objective.	
62	In discussions I'm more likely to adopt a 'low profile' than to take the lead and	

	do most of the talking.	
63	I like to be ale to relate current actions to a longer term bigger picture.	
64	When things go wrong I am happy to shrug it off and 'put it down to experience'.	
65	I tend to reject wild, off-the-top-of-the-head ideas as being impractical.	
66	It's best to 'look before you leap'.	
67	On balance I do the listening rather than the talking.	
68	I tend to be tough on people who find it difficult to adopt a logical approach.	
69	Most times I believe the end justifies the means.	
70	I don't mind hurting people's feelings so as the job gets done.	
71	I find the formality of having specific objectives and plans stifling.	
72	I'm usually the 'life and soul' of the party.	
73	I do whatever is expedient to get the job done.	
74	I quickly get bored with methodical, detailed work.	
75	I am keen on exploring the basic assumptions, principles and theories underpinning things and events.	
76	I'm always interested to find out what other people think.	
77	I like meetings to be run on methodical lines, sticking to laid down agenda, etc.	
78	I steer clear of subjective or ambiguous topics.	
79	I enjoy the drama and excitement of a crisis situation.	
80	People often find me insensitive to their feelings.	

Source: Honey & Mumford, 1982

APPENDIX 5 – QUESTIONNAIRE 4

'End User Satisfaction' Questionnaire

Please fill in the questionnaire by placing a circle on the appropriate number for each item as shown below. Use either a pen or a pencil. Circle only one number per item.

Example:

The following is a set of terms with respect to end user training environment. Please circle the appropriate number to denote your level of agreement/disagreement:

Disagree
Agree

	Disagree				Agree
1. The training program is enjayable	1	2	3	4	5
2. The training manual is easy to understand	1	2	3	4	5

Disagree
Agree

	Disagree				Agree
1. The training environment provided the precise information I needed	1	2	3	4	5
2. The training environment is user friendly	1	2	3	4	5
3. The training material provided met the needs of learning	1	2	3	4	5
4. The information was presented in a timely manner	1	2	3	4	5
5. The system is accurate	1	2	3	4	5
6. The information content met my needs for learning	1	2	3	4	5
7. The training materials was presented in a useful format	1	2	3	4	5
8. The information was presented clearly	1	2	3	4	5
9. The training materials provided sufficient information	1	2	3	4	5
10. The computer system was easy to use	1	2	3	4	5
11. I was satisfied with the accuracy of the information	1	2	3	4	5
12. The training environment provided up-to-date information	1	2	3	4	5

Source: Igbaria, 1990

Appendix 6 – Questionnaire 5

Based on the training provided to you in the last session and based on the experiment provided to you in this session, please indicate your level of agreement/disagreement on the following items by placing a circle on the number as shown in the example.

Example:
The following is a set of terms with respect to end user training environment. Please circle the appropriate number to denote your level of agreement/disagreement:

Disagree
Agree

1.	The training program is enjayable	1	2	3	4	5
2.	The training manual is easy to understand	1	2	3	4	5

Disagree

Agree

Learning to use computers						
a)	I find it easy to learn the operating systems commands	1	2	3	4	5
b)	I find it easy to learn the mouse operations	1	2	3	4	5
c)	I find it easy to learn the keyboard operations	1	2	3	4	5
d)	I find it easy to learn the Application Software commands	1	2	3	4	5
e)	I find it easy to learn the meaning of computer interfaces					
Becoming Skillful at using computers						
a)	It is easy for me to become skillful at using the operating systems	1	2	3	4	5
b)	It is easy for me to become skillful at using the mouse	1	2	3	4	5
c)	It is easy for me to become skillful at using the keyboard	1	2	3	4	5
d)	It is easy for me to become skillful at using the application software	1	2	3	4	5
e)	It is easy for me to become skillful at using the application interfaces	1	2	3	4	5
Getting work out of computers						
a)	I find it easy to execute various operating systems commands to get my work done	1	2	3	4	5
b)	I find it easy to execute various mouse options to get my work done	1	2	3	4	5
c)	I find it easy to execute various keystrokes to get my work done	1	2	3	4	5
d)	I find it easy to execute various available options in the application to get my work done	1	2	3	4	5
e)	I find it easy to execute various application interfaces to get my work done	1	2	3	4	5
Operating the Computers						
a)	I find it easy to use the operating systems commands	1	2	3	4	5
b)	I find it easy to use the mouse operations	1	2	3	4	5
c)	I find it easy to use the keyboard operations	1	2	3	4	5
d)	I find it easy to use the Application Software commands	1	2	3	4	5
e)	I find it easy to use the application interfaces	1	2	3	4	5

Using the Training Materials

		1	2	3	4	5
a)	The training materials were easy to read	1	2	3	4	5
b)	The training materials provided an easy flow while working on tasks	1	2	3	4	5
c)	The training materials were easy to understand	1	2	3	4	5
d)	The training materials consisted of tasks that were easy to use	1	2	3	4	5
e)	The training materials lead me through examples, provided answers to by doubts, and solved problems in an easy manner	1	2	3	4	5
f)	The training materials demonstrated techniques for the trainees to follow in an easy manner	1	2	3	4	5
g)	The training materials answered my questions when necessary, in an easy way	1	2	3	4	5
h)	The training approaches provided me step-by-step instructions, which were easy to understand	1	2	3	4	5

APPENDIX 7 – SAMPLE TRAINING MATERIAL

TRAINING MATERIAL

Introduction:

This material presents the basics of project management such as scheduling using MS PROJECT. The material is targeted at both beginners and experienced end users, who have very limited project management software knowledge. The material will expose project management concepts by creating a simple project. Necessary theoretical concepts and information aids will be presented to help the overall learning process.

Topic(s):

1. What is project management?
2. What are the advantages of using project management software?
3. What are the project management scheduling techniques?

Objectives:

The learning objectives of this training material are:

- To understand the concepts of project management
- To appreciate the advantages of a project management software
- To understand the functional elements of a project management software
- To create a simple project

Contents:

What is Project Management?

The term Project management refers to managing the activities that lead to the successful completion of a project. Project management is the application of management principles to plan, organize, staff, control, and direct resources of an organization or individual in pursuit of a temporary or one-time specific goal.
The person who is responsible of the project, called project manager, will plan the various actions or tasks that will achieve the project objectives. While achieving the project objectives, the project manager will organize the available resources to carry out the plan.

What are the advantages of using project management software?

Project management software can be a helpful tool in managing a project with the following advantages:

- Develop a better plan
- Calculate easier and reliable projections
- Detect inconsistencies and problems in the plan
- Communicate the plan to others
- Track progress and detect potential difficulties

What are the project management scheduling techniques?

Project management software applications use a number of scheduling techniques when scheduling tasks and resources. Gaining an overview of these techniques can be useful to coordinate a project. The following are some of the most used techniques:

The Critical Path Method (CPM)

This is the fundamental scheduling method used in project management. To use the CPM method, one must identify all the tasks that need to be completed, stipulate how

long does that take for each task (the duration of the task), and define all sequencing requirements that govern when one can schedule work on the task. A sequencing requirement refers to a requirement that a task cannot begin until another task is completed or at least has already begun.
The CPM method takes into account all the task data, and calculates the overall duration of the project by calculating the combined duration of the tasks when all tasks are chained together in the required sequences.
The tasks can be conducted in a linear or concurrent fashion, or in a parallel fashion. The critical tasks are the ones, which determines the completion of the project. All the critical tasks need to be finished in order for a project to arrive completion. A sequence of critical tasks is called a critical path.
Certain tasks may contain delay terms in completion. This is called the slack. When a task consists of slack, it cannot be critical. If the project needs to be completed on schedule, then critical tasks cannot assume slack.

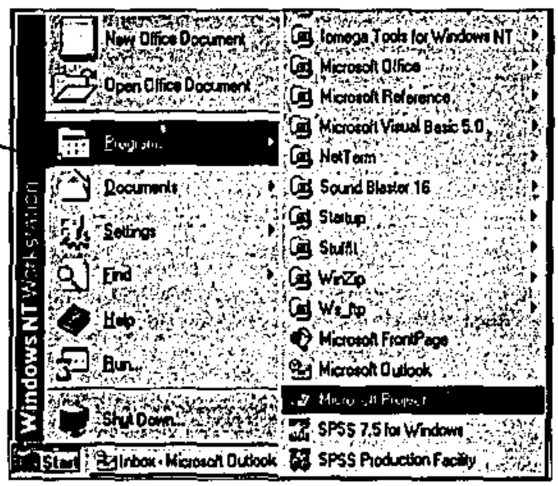
Resource Driven Scheduling

Resource driven scheduling is scheduling a task based on available resources. Certain tasks, no matter what the resource allocation is, will not be completed before the specified duration. On the other hand, allocating additional resources will complete certain other tasks. In other words, these tasks will change in terms of duration, while additional resources are allocated. Such tasks scheduling are called resource driven.

Basics of Microsoft PROJECT

The training material will provide skills to understand:

1. How to interpret and navigate the screen display;
2. How to use the menu (and icon) commands; and
3. How to select tasks, resources, or individual task fields.



<u>To start Microsoft Project program:</u>

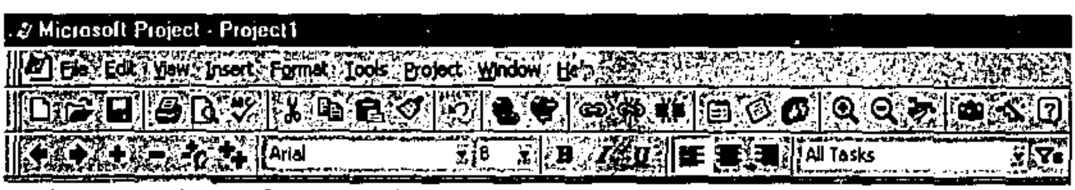
1. Go to START tab on Windows 95
2. Select Programs
3. Select Microsoft
4. Select Microsoft Project

OR

1. Go to Windows 95 desktop
2. Double click on MS Project icon

<u>The Menu Bar</u>

The Project menu bar is similar to menu bars of other Microsoft applications such as Word, Excel and PowerPoint. The following is a



partial screen dump of the menu bar:

The Tool Bar

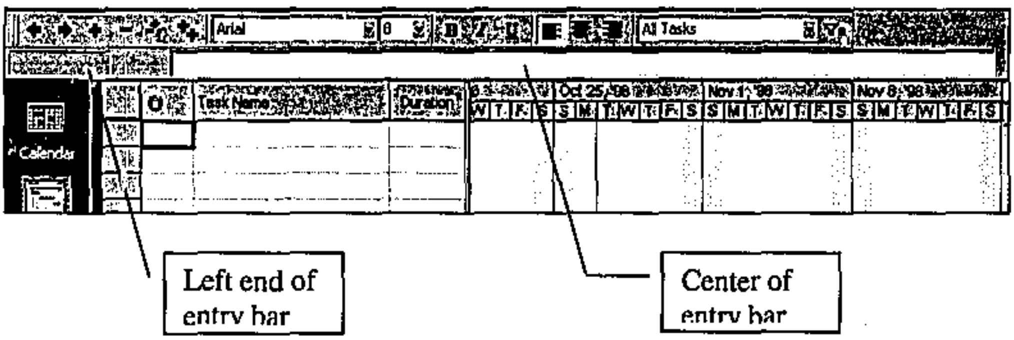
The MS Project toolbar consists of buttons that can be activated with the mouse to provide shortcuts to frequently used menu choices or special functions.

Button	Action
	Opens a new project file.
	Displays the Open dialog box so that you can open an existing project file.
	Saves changes made to the active project file.
	Prints the active view of the current project.
	Displays each page of the active view as it will look when printed. The status bar at the bottom of the screen shows the current page number and the total number of pages in the selected view.
	Checks the spelling of words in your project.
	Deletes the selection and places it on the Clipboard.
	Copies the selection and places it on the Clipboard.
	Pastes the contents of the Clipboard to the insertion point.
	Copies the formatting of the selected fields and applies it to the fields you specify.
	Reverses the last command you chose, if possible, or deletes the last entry you typed.
	Links the selected tasks with a finish-to-start dependency.
	Unlinks the selected tasks.
	Initiates the splitting of a task. The pointer becomes a ✥, which you then position on the task bar you want to split. Drag the task bar to the right to split the task.
	Displays task or resource information that you can edit.
	Displays the Notes tab in the Information dialog box of the task or resource, where you can write a note relevant to the task or resource.
	Displays the Resource Assignment dialog box, where you can add, change, and remove resource assignments.
	Shows a smaller time increment on the timescale.
	Shows a larger time increment on the timescale.
	Moves to the area on the Gantt Chart containing the bar for the selected task.
	Copies the selected information as an object.
	Starts the GanttChartWizard so that you can customize the appearance of the Gantt Chart. The GanttChartWizard guides you through a series of dialog boxes, and then modifies the Gantt Chart according to your answers.
	Displays the Office Assistant.

The Entry Bar

The entry bar is on the line below the toolbars. The entry bar performs the following functions:

1. The left end displays progress messages to let you know when Microsoft Project is engaged in calculating, opening and saving files.



2. The center of the entry bar contains an area where data entry and editing takes place.

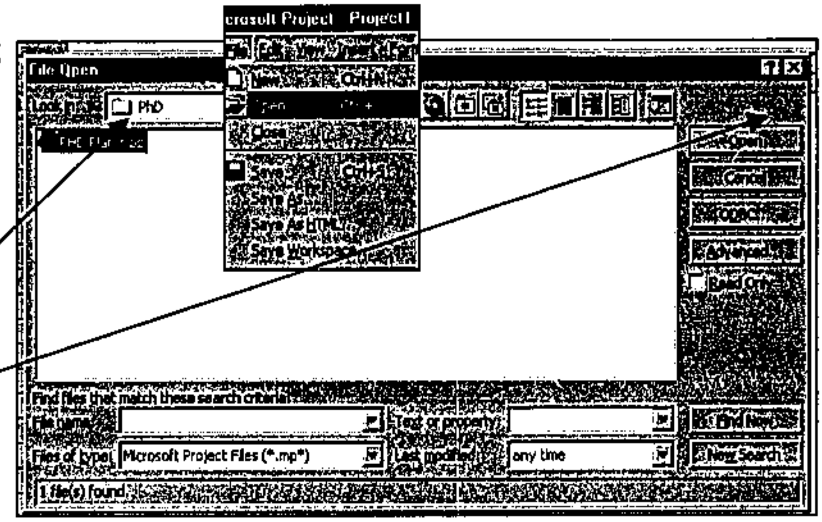
How to enter data in MS Project?

To enter data in MS Project, follow these steps:

1. Choose the field where you want the data to appear by using keyboard or mouse and begin typing
2. In the entry area make any needed changes to data before you place the data in the field
3. To enter data, press "ENTER", choose "ENTER BOX" to the left of the entry area OR use the mouse to select another field

4. To cancel an entry while typing, press "ESC" key or CANCEL BOX

Opening an existing file



1. Go to File
2. Select Open (to display dialogue box)
3. Locate the file by navigating folders
4. Double Click on the file to open OR Click OPEN button

Creating a New Project (Opening a New File)

1. Choose File from menu options
2. Select New
3. OK

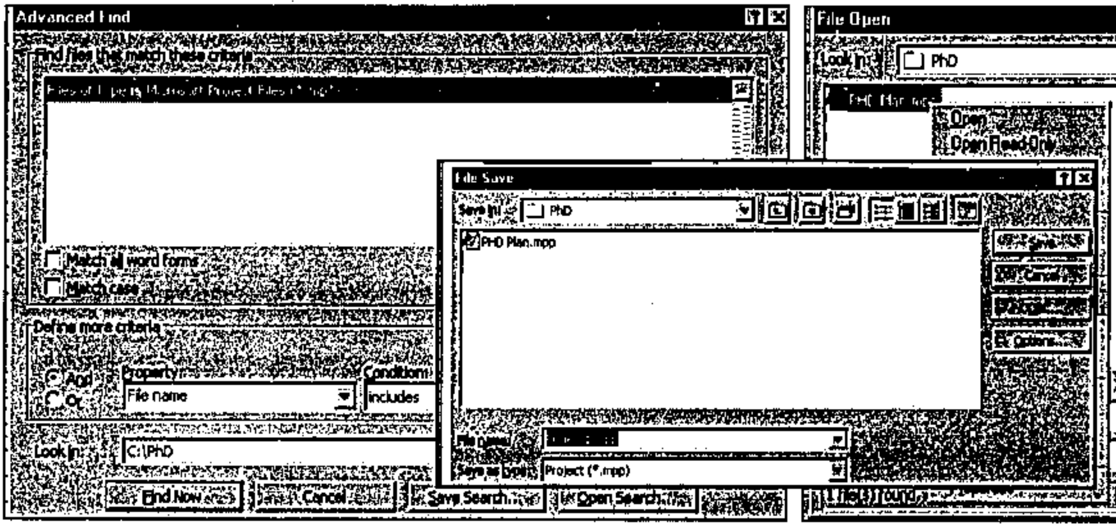
Closing a File

1. Choose File
2. Select Close

Using the File Open Dialogue Box to Search for a File

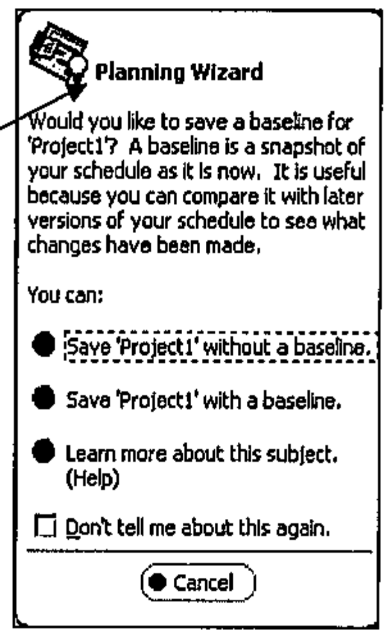
The file open dialogue box provides advanced search features to locate a file. This feature comes handy when a user doesn't remember the file name. Users can search files by name, by type, by location or by the date the files were created or last saved. Alternatively, if information is entered in the property dialogue box, then this information can be used to locate a file.

The advanced option in the open dialogue box provides advanced features to locate a file. Once a file is located, users have the option to place the mouse pointer on the located file, RIGHT CLICK the mouse to execute various options such as print, rename and view the properties.



Saving a file

When a work is saved in Project, it is initially saved as a baseline. This option is provided to track certain changes in the future. To save your work, follow these steps:



1. Go to File
2. Select Save
3. Check "CANCEL" button in the Planning Wizard which appears at this point of time
4. Provide a suitable name in the File Name box
5. Click Save

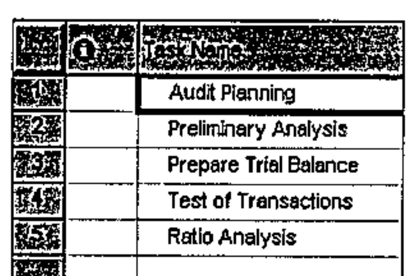
Examples

The following examples will provide functional knowledge about MS PROJECT.

<u>How to create a new project</u>

To create a new project

1. Go to File
2. Select New OR CTRL+N or click on 
3. Click OK in the dialogue box



How to enter data in the project form

Entry of task names

1. Select the cell beneath task name
2. Enter the text "Audit Planning"

3. Press ENTER Key OR move MOUSE to next cell down or click
4. Enter the details as shown in the screen dump

		Task Name	Duration
1		Audit Planning	2 days
2		Preliminary Analysis	1 day
3		Prepare Trial Balance	3 days
4		Test of Transactions	3 days
5		Ratio Analysis	2 days

Entry of Duration

1. Go to the first cell beneath the duration tab
2. Double click on the cell to enter a value "2"
3. Press ENTER key or select next cell down by mouse click or PRESS DOWN ARROW KEY
4. Fill in the cells as shown

Changing Date Formats

1. Go to Tools
2. Click on Options
3. Select the required date format

Creating tasks in the Gantt Chart

Enter a task name by following the steps mentioned in "Entry of task names" above

OR

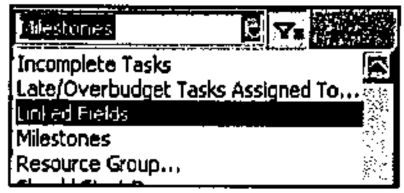
1. Select a cell in the task name column
2. Type the task name using a combination of keyboard characters and spaces
3. Complete the cell entry by pressing the ENTER Key, or by clicking the ENTER BUTTON in the entry bar (green color ✓ symbol), or by selecting another cell.

Note: Task name can be a maximum of 255 characters including spaces

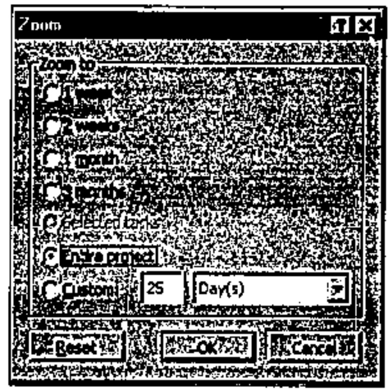
Entering Task Duration

1. Go to Duration column
2. Type the duration in numbers

3. Use the following abbreviation for the time units:



    - M or em for minutes
    - H or eh for hours
    - D or ed for days
    - W or ew for weeks



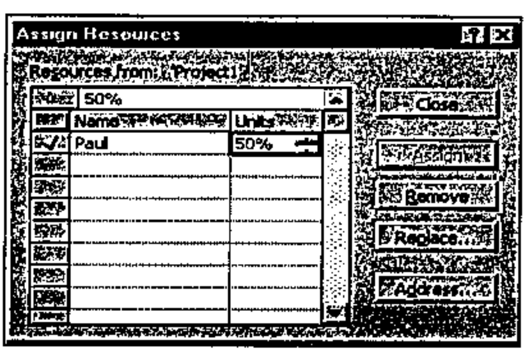
4. Complete the entry by pressing the ENTER Key or by selecting another cell

Entering Milestones

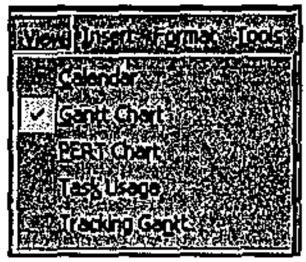
1. Open project if not opened already
2. Choose View, Gantt Chart
3. Choose Milestones from the filters drop down list on the format toolbar (as shown)
4. Choose View, Zoom
5. Check Entire Project option button
6. Choose OK

Entering Resources

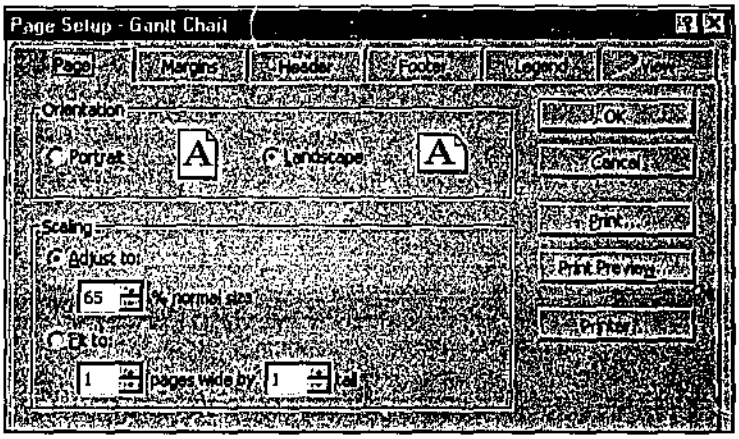
1. Select the task for which resources need to be entered
1. Click on the resource assignment button 
2. Type in the resource name
3. Type in the unit in terms of 0, 50 or 100%
4. Click Assign tab
5. Ensure a ✓ mark is placed next to the resource assigned
6. Click close tab



Viewing GANTT Chart



1. Go to View menu
2. Ensure the Gantt Chart tab is checked
3. Click on Print Preview icon
4. When the schedule is big, the print preview would span more than one page. MS Project provides provisions to contain the GANTT view into one page. To do this:
5. Go to File menu



6. Go to Page Setup option
7. Select the Page tab
8. Ensure Fit to tab is checked with 1 page wide by 1 page tall
9. Click OK
10. Click on Print Preview icon
11. Once viewed, CLOSE Print Preview

How to Link Tasks

1. Select the tasks you want to link
2. Use SHIFT Key to select multiple tasks by clicking the first task, depressing the shift key and then selecting the last task
3. Click the  icon from the menu

NOTE: When the tasks are linked, you would notice a  symbol like this near the left side of the main task. In the

		Task Name	Duration	Start	Finish	Predecessors
1		⊟ **Raj's Phd Schedule for 1998 - 1**	**112 days**	**Fri 7/10/98**	**Mon 12/14/98**	
2		⊟ **Theory Development**	**36 days**	**Fri 7/10/98**	**Fri 8/28/98**	
3		Learning & Training	19 days	Fri 7/10/98	Wed 8/5/98	
4		Previous Studies	15 days	Mon 8/10/98	Fri 8/28/98	3
5		⊟ **Research Design**	**29 days**	**Mon 9/7/98**	**Thu 10/15/98**	**2**
6		Classification of Subjects	15 days	Mon 9/7/98	Fri 9/25/98	
7		Needs Identification & Analy	10 days	Fri 10/2/98	Thu 10/15/98	6

predecessor column, the task priority will be displayed.

END OF TRAINING SESSION

Exercise

Create the following schedule using Microsoft Project:

Task Name	Duration	Resources
Survey Forms	3 days	Smith (100%)
Survey Admin	8 days	Smith, Jones (50 % each)
Data Entry Milestone	3 days	Sarah (100 %)
Analysis	2 days	Smith, Garter (50 % each)
Report Milestone	2 days	Garter (100 %)

Produce the schedule in such a way that a GANTT chart with milestones is shown.

Solution to Exercise (Not given to participants)

<u>Open MS Project</u>

1. Go to START tab on Windows 95
2. Select Programs (a score of ½ unit)
3. Select MS Project (a score of ½ unit)

OR

1. Go to Windows 95 desktop
2. Double click MS Project icon (a score of 1 unit)

<u>Enter Task Details</u>

1. Select the cell beneath task name (a score of 1 unit)
2. Enter the text "Audit Planning" (a score of 1 unit)
3. Press ENTER Key OR move MOUSE to next cell down or click (a score of ½ unit)
5. Go to the first cell of beneath the duration tab (a score of 1 unit)
6. Double click on the cell to enter a value ((a score of ½ unit))
7. Press ENTER key or select next cell down by mouse click or PRESS DOWN ARROW KEY

Enter Resource Details

1. Select the task for which resources need to be entered (a score of ½ unit)
2. Click on the resource assignment button (a score of 1 unit)
3. Type in the resource name (a score of 1 unit)
4. Type in the unit in terms of 0, 50 or 100% or use the pull-down scrollbar (a score of 1 unit)
5. Click Assign tab (a score of 1 unit)
6. Ensure a ✓ mark is placed next to the resource assigned (a score of ½ unit)
7. Click close tab (a score of 1 unit)

Hand-On Tasks 1

Create a task schedule as shown in the diagram. Once the task is created, display the task in the form of a GANTT chart.

		Task Name	Duration	Start	Finish	Predece
1		⊟ **Raj's Phd Schedule for 1998 - 1999**	**112 days**	**Fri 7/10/98**	**Mon 12/14/98**	
2		⊟ **Theory Development**	**36 days**	**Fri 7/10/98**	**Fri 8/28/98**	
3		Learning & Training	19 days	Fri 7/10/98	Wed 8/5/98	
4		Previous Studies	15 days	Mon 8/10/98	Fri 8/28/98	3
5		⊟ **Research Design**	**29 days**	**Mon 9/7/98**	**Thu 10/15/98**	**2**
6		Classification of Subjects	15 days	Mon 9/7/98	Fri 9/25/98	
7		Needs Identification & Analysis	10 days	Fri 10/2/98	Thu 10/15/98	6
8		⊟ **Material Preparation**	**15 days**	**Mon 11/23/98**	**Fri 12/11/98**	
9		Material Verification	10 days	Mon 11/23/98	Fri 12/4/98	5
10		Material Refinement	5 days	Mon 12/7/98	Fri 12/11/98	9
11		Ethics Clearance	1 day	Mon 12/14/98	Mon 12/14/98	10

Hand-On Tasks 2

In the above task schedule, link tasks 2 through 4, tasks 5 through 7 and tasks 8 through 11. Enter milestones for tasks 2, 5 and 8. Once the milestones are entered, save the file in a floppy under your name.

Hands-On Task 3

Open a new project on to a floppy under your name. Create the following task schedule.

		Task Name	Duration	Start	Finish
1		⊟ **Raj's Phd Schedule for 1998 - 1999**	**112 days**	**Fri 7/10/98**	**Mon 12/14/98**
2		⊟ **Theory Development**	**36 days**	**Fri 7/10/98**	**Fri 8/28/98**
3		Learning & Training	19 days	Fri 7/10/98	Wed 8/5/98
4		Previous Studies	15 days	Mon 8/10/98	Fri 8/28/98
5		⊟ **Research Design**	**29 days**	**Mon 9/7/98**	**Thu 10/15/98**
6		Classification of Subjects	15 days	Mon 9/7/98	Fri 9/25/98
7		Needs Identification & Analysis	10 days	Fri 10/2/98	Thu 10/15/98
8		⊟ **Material Preparation**	**15 days**	**Mon 11/23/98**	**Fri 12/11/98**
9		Material Verification	10 days	Mon 11/23/98	Fri 12/4/98
10		Material Refinement	5 days	Mon 12/7/98	Fri 12/11/98
11		Ethics Clearance	1 day	Mon 12/14/98	Mon 12/14/98

1. Change the name of task 2 to Development of Theory. Change the start date to Mon 12 October 1998. Keep the duration as it is. Ensure that the date format is consistent with other tasks.
2. Change the duration to task 9 to 8 days. Advance the finish of task 9 to the new date 2 December 1998.
3. Save the document in your name. Again save the document in your name + backup. For example the document that is saved in my name would be Raj Backup.

Hands-On Task 4

Use the previous task to display the GANTT chart on a custom page as defined below:

Date Format:	Change the date format to Month followed by date as in January 31
Header:	MS Project hands-on testing
Footer:	<My Name> left aligned, <Date> right aligned, <Page No: #> center aligned
Margins:	Provide margins of 1" on all four sides
Scaling:	Scale the page to 81% of the original size
Legend:	Provide a legend of "Assisting a study to determine IT training Outcomes" with a legend alignment of center and width of 2"

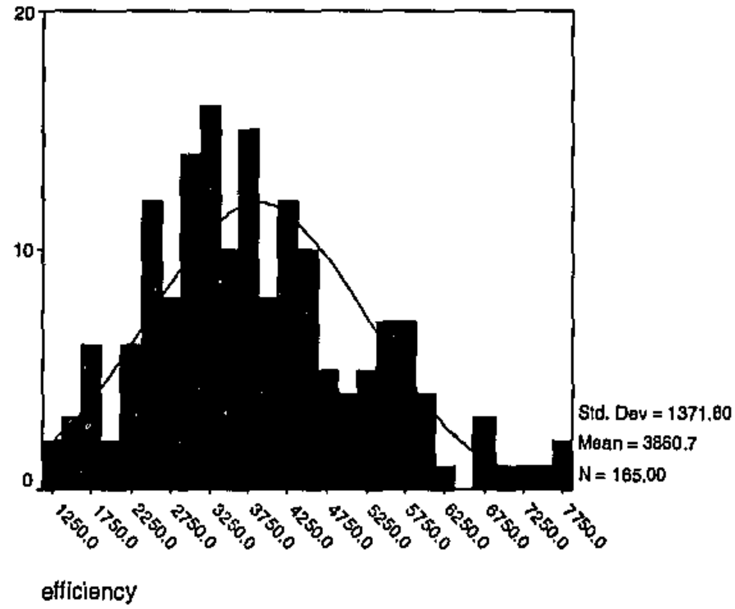
Response Sheet

Your Name: ____________________________________

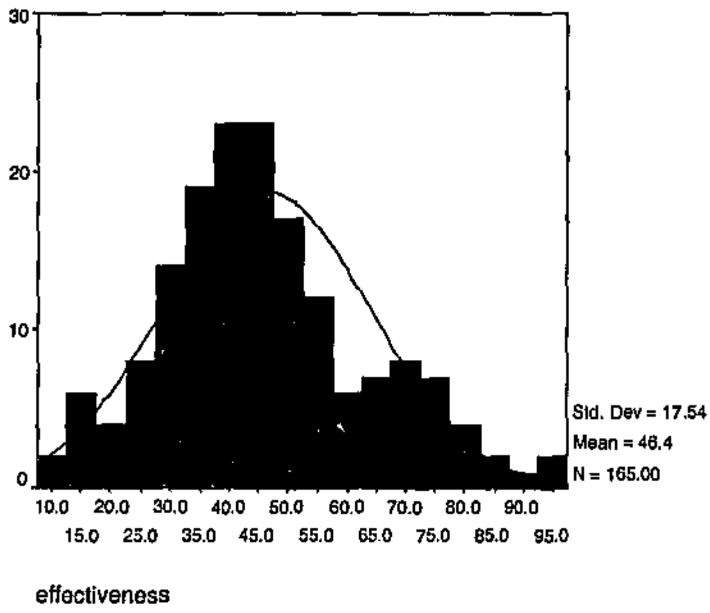
Please mark the column ***Response*** with either a (x) or a (✓).

Processes involved in completing the task	Response	Comments if any
1. Did you find the menu-based information useful?		
2. Did you find the DMI (icon) useful?		
3. Were you able to progress with reasonable accuracy?		
4. Were you able to understand the concept behind each steps performed?		
5. Did you backtrack at any point of time?		
6. Were the menu items meaningful?		
7. Were the icons meaningful?		
8. Did you understand the significance of the dialogue boxes (where applicable)		
9. Did you use menu interfaces predominantly to complete the task(s)?		
10. Did you use the icons predominantly to complete the task(s)?		
11. Did the instructions provided in the training material helped you to complete the task?		
12. Did you have a need to explore to complete the task(s)?		
13. Did you follow the instructions provided in the training manual to complete the tasks?		
14. Did you explore various options to complete the tasks?		

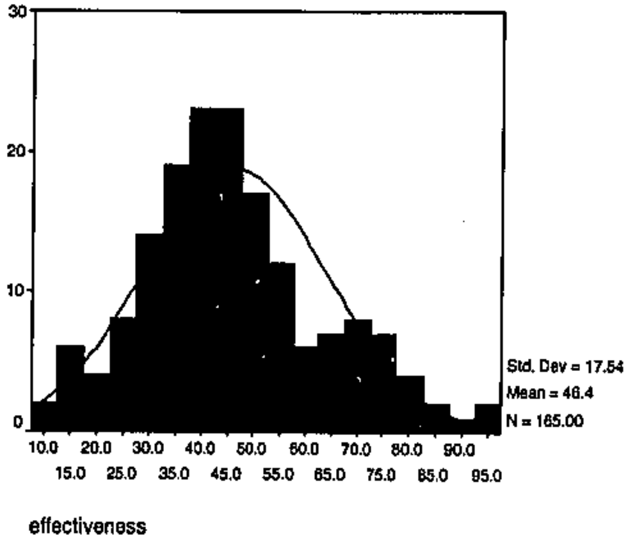
APPENDIX 8 – NORMAL DISTRIBUTION PLOT



Picture A8-1 Normal Plot for efficiency



Picture A8-2 Normal Plot for effectiveness



Picture A8-3 Normal Plot for ease of use

APPENDIX 9 – VISUAL BASIC CODE

```
Option Explicit
Sub LSQ_Data()
'
' LSQ_Data Macro
' Macro recorded 27/06/99 by Raj Gururajan
'
Dim Row, Col As Integer
Dim ActTotal, RefTotal, TheTotal, PraTotal As Integer

' calculate Activist Total

For Row = 2 To 179
ActTotal = 0
   If Cells(Row, 5).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 7).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 9).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 13).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 20).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 26).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 27).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 35).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 37).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 41).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 43).Value = 1 Then
```

```
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 46).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 48).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 51).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 61).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 67).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 74).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 75).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 77).Value = 1 Then
      ActTotal = ActTotal + 1
    End If
    If Cells(Row, 82).Value = 1 Then
      ActTotal = ActTotal + 1
    End If

  Cells(Row, 84).Value = ActTotal
  Next Row
  '--------------------------------------
  For Row = 2 To 179
  RefTotal = 0
    If Cells(Row, 10).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 16).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 18).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 19).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 28).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
```

```
    If Cells(Row, 31).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 32).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 34).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 36).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 39).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 42).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 44).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 49).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 55).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 58).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 63).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 65).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 69).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 70).Value = 1 Then
      RefTotal = RefTotal + 1
    End If
    If Cells(Row, 79).Value = 1 Then
      RefTotal = RefTotal + 1
    End If

Cells(Row, 85).Value = RefTotal
Next Row
'------------------------------
For Row = 2 To 179
```

```
TheTotal = 0
  If Cells(Row, 4).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 7).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 11).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 15).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 17).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 21).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 23).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 25).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 29).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 33).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 45).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 50).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 54).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 60).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 64).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 67).Value = 1 Then
    TheTotal = TheTotal + 1
  End If
  If Cells(Row, 71).Value = 1 Then
```

```
      TheTotal = TheTotal + 1
    End If
    If Cells(Row, 78).Value = 1 Then
      TheTotal = TheTotal + 1
    End If
    If Cells(Row, 80).Value = 1 Then
      TheTotal = TheTotal + 1
    End If
    If Cells(Row, 81).Value = 1 Then
      TheTotal = TheTotal + 1
    End If

Cells(Row, 86).Value = TheTotal
Next Row
'-------------------------
For Row = 2 To 179
PraTotal = 0
    If Cells(Row, 8).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 12).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 14).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 22).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 24).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 30).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 38).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 40).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 47).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 52).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
    If Cells(Row, 53).Value = 1 Then
      PraTotal = PraTotal + 1
    End If
```

```
  If Cells(Row, 56).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 57).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 59).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 62).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 68).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 72).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 73).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 76).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 84).Value = 1 Then
    PraTotal = PraTotal + 1
  End If

Cells(Row, 87).Value = PraTotal
Next Row

'
End Sub
Sub LSQ_Final()
'
' LSQ_Final Macro
' Macro recorded 5/28/99 by rgururajan
'
Dim Row As Integer
Dim AF, RF, TF, PF As Long

For Row = 4 To 189
AF = Abs(Cells(Row, 84) - 8.6)
RF = Abs(Cells(Row, 85) - 14.2)
TF = Abs(Cells(Row, 86) - 12.2)
PF = Abs(Cells(Row, 87) - 12.7)

If AF < RF < TF < PF Then
  Cells(Row, 88).Value = "Activist"
End If
```

```
If RF < AF < TF < PF Then
   Cells(Row, 88).Value = "Reflector"
End If
If TF < AF < RF < PF Then
   Cells(Row, 88).Value = "Theorist"
End If
If PF < AF < RF < TF Then
   Cells(Row, 88).Value = "Pragmatist"
End If

Next Row
'
End Sub

'
End Sub
```

```
Option Explicit
Sub LSQ_Data()
'
' LSQ_Data Macro
' Macro recorded 27/06/99 by Raj Gururajan
'

Dim Row, Col As Integer
Dim ActTotal, RefTotal, TheTotal, PraTotal As Integer

' calculate Activist Total

For Row = 2 To 179
ActTotal = 0
  If Cells(Row, 5).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 7).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 9).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 13).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 20).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 26).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 27).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 35).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 37).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 41).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 43).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 46).Value = 1 Then
    ActTotal = ActTotal + 1
  End If
  If Cells(Row, 48).Value = 1 Then
```

```
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 51).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 61).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 67).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 74).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 75).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 77).Value = 1 Then
      ActTotal = ActTotal + 1
   End If
   If Cells(Row, 82).Value = 1 Then
      ActTotal = ActTotal + 1
   End If

Cells(Row, 84).Value = ActTotal
Next Row
'--------------------------------------
For Row = 2 To 179
RefTotal = 0
   If Cells(Row, 10).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 16).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 18).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 19).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 28).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 31).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
   If Cells(Row, 32).Value = 1 Then
     RefTotal = RefTotal + 1
   End If
```

```
  If Cells(Row, 34).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 36).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 39).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 42).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 44).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 49).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 55).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 58).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 63).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 65).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 69).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 70).Value = 1 Then
    RefTotal = RefTotal + 1
  End If
  If Cells(Row, 79).Value = 1 Then
    RefTotal = RefTotal + 1
  End If

Cells(Row, 85).Value = RefTotal
Next Row
'-------------------------------
For Row = 2 To 179
TheTotal = 0
  If Cells(Row, 4).Value = 1 Then
     TheTotal = TheTotal + 1
  End If
  If Cells(Row, 7).Value = 1 Then
     TheTotal = TheTotal + 1
```

```
End If
If Cells(Row, 11).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 15).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 17).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 21).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 23).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 25).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 29).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 33).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 45).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 50).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 54).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 60).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 64).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 67).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 71).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 78).Value = 1 Then
   TheTotal = TheTotal + 1
End If
If Cells(Row, 80).Value = 1 Then
```

```
      TheTotal = TheTotal + 1
   End If
   If Cells(Row, 81).Value = 1 Then
      TheTotal = TheTotal + 1
   End If

Cells(Row, 86).Value = TheTotal
Next Row
'-------------------------
For Row = 2 To 179
PraTotal = 0
   If Cells(Row, 8).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 12).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 14).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 22).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 24).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 30).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 38).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 40).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 47).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 52).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 53).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 56).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
   If Cells(Row, 57).Value = 1 Then
      PraTotal = PraTotal + 1
   End If
```

```
  If Cells(Row, 59).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 62).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 68).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 72).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 73).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 76).Value = 1 Then
    PraTotal = PraTotal + 1
  End If
  If Cells(Row, 84).Value = 1 Then
    PraTotal = PraTotal + 1
  End If

Cells(Row, 87).Value = PraTotal
Next Row

'
End Sub
Sub LSQ_Final()
'
' LSQ_Final Macro
' Macro recorded 5/28/99 by rgururajan
'
Dim Row As Integer
Dim AF, RF, TF, PF As Long

For Row = 4 To 189
AF = Abs(Cells(Row, 84) - 8.6)
RF = Abs(Cells(Row, 85) - 14.2)
TF = Abs(Cells(Row, 86) - 12.2)
PF = Abs(Cells(Row, 87) - 12.7)

If AF < RF < TF < PF Then
  Cells(Row, 88).Value = "Activist"
End If
If RF < AF < TF < PF Then
  Cells(Row, 88).Value = "Reflector"
End If
If TF < AF < RF < PF Then
  Cells(Row, 88).Value = "Theorist"
End If
```

```
If PF < AF < RF < TF Then
   Cells(Row, 88).Value = "Pragmatist"
End If

Next Row
'
End Sub

'
End Sub
```