COMPARING THE MEANING OF THE LEARNABILITY PRINCIPLE FOR CHILDREN AND ADULTS

by

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I declare that COMPARING THE MEANING OF THE LEARNABILITY PRINCIPLE FOR CHILDREN AND ADULTS is my own work and that all the sources that l have used or quoted have been indicated and acknowledged by means of complete references.

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SIGNATURE **DATE**

(Mrs B Chimbo)

SUMMARY

The learnability principle relates to improving usability of software, performance and productivity. It was formulated mainly for the adult user group. Children represent an important user group, but fewer guidelines exist for their educational and entertainment applications. This study compares these groups, addressing the question: “Does learnability of software interfaces have a different meaning for children and adults?”.

A literature survey conducted on learnability and learning processes considered the meaning of learnability across generations. Users learning software systems were observed in a usability laboratory where eye tracking data could also be recorded.

Insights emerged, from data analysis, showing different tactics when children and adults approached unfamiliar software and revealing aspects of interfaces they approached differently. The findings will help designers distinguish varying needs of users and improve learnability. An additional subprinciple of learnability, ‘engageability’, is proposed. Factors that make products engaging for children are different from those engaging adults.

Key terms: Eye Tracking, Human Computer Interaction, Child Computer Interaction, Learning Strategies, Learning Theories, Learnability, Software Applications, Usability.

OPSOMMING

Die leerbaarheidsbeginsel hou verband met die verbetering van die bruikbaarheid van sagteware, werkverrigting en produktiwiteit. Dit was hoofsaaklik vir die volwasse gebruikersgroep geformuleer. Kinders verteenwoordig in belangrike gebruikersgroep, maar minder riglyne is vir hulle opvoedkundige en vermaaktoepassings beskikbaar. Hierdie studie vergelyk hierdie groepe en speek die volgende vraag aan: "Het leerbaarheid van sagtewarekoppelvlakke verskillende betekenisse vir kinders en volwassenes?"

'n Literatuuroorsig oor leerbaarheid en leerprosesse is uitgevoer met in ag neming van die betekenis van leerbaarheid vir verskillende generasies. Gebruikers is waargeneem in 'n bruikbaarheidslaboratorium terwyl hulle geleer het om sagetware te gebruik. Data in verband met oogbewegings op die skerm is ook opgeneem.

Insigte wat uit die data-analise te voorskyn gekom het toon verskillende taktieke wanneer kinders en volwassenes met onbekende sagteware gekonfronteer word. Hulle benadering tot sekere aspekte van 'n koppelvlak verskil. Die bevindinge sal ontwerpers help om te onderskei tussen wisselende gebruikersbehoeftes. 'n Addisionele sub-beginsel van leerbaarheid, naamlik 'engageability' word voorgestel. Faktore wat 'n produk aantreklik maak vir kinders is verskillend van dit wat volwassenes aantrek.

Sleutelterme: Bruikbaarheid, Kind-rekenaar interaksie, Leerbaarheid, Leerteorieë, Leerstrategieë, Mens-rekenaar interaksie, Oogbeweging, Sagtewaretoepassings,

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STYLE OF WRITING

Writing style:

- *Use of both 'I' and 'the researcher'*

In describing the research process and results in this dissertation, I have used both the first person 'I' and 'the researcher' to show my involvement in the research.

- *Use of 'he' and 'she'*

Generally, in discussing my data, I used the term 'he'. However, when referring to the participants in my discussion and presentation of the results, I used he/she.

CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 Introduction

The principles and guidelines for software design are generally aimed at products for adults, with the emphasis on improving work performance and productivity (Pretorius, Gelderblom and Chimbo, 2010). Children represent an important user group for software and technology but few guidelines exist to help in their education and entertainment. Preece, Rogers and Sharp (2007) support the above statement by saying that usability goals include effectiveness, efficiency and utility, which are goals of products that are not necessarily for young children. Similarly, the way Dix, Finlay, Abowd and Beale (2004) discuss their usability principles of learnability, flexibility and robustness, makes them more naturally applicable to productivity-enhancing products for adults.

Chiasson and Gutwin (2005) argue that many design principles used for user interfaces designed for adults cannot be applied to children’s products, because the needs, skills, and expectations of this user population are drastically different from those of adults. Various researchers and Human Computer Interaction (HCI) specialists have, however, proposed guidelines that are aimed at design for young children (Malone, 1982; Grammenos and Stephanidis, 2002; Fishel, 2001; Baumgarten, 2003). In recent years, an increasing number of designers have started developing design principles for children, but this work has not been consolidated in a single source (Chiasson and Gutwin, 2005).

Gelderblom (2008) collated an extensive range of guidelines into a framework for the design of technology for young children, which applies only to the 5 to 8 years age group. There is currently an initiative by designers to make design principles that are applicable to products aimed at users of different age groups.

Dix et al. (2004) provide interface designers with a comprehensive set of high-level directing principles with the aim of improving the usability of systems. The authors divide their principles into three categories, namely learnability, flexibility and robustness (Gelderblom, 2008). Learnability is one of the quality components of usability that refers to a measure of the degree to which a user interface can be learnt quickly and effectively. The focus of this study is to investigate the meaning of the learnability principle in the context of usage of software applications. Learning time is the typical measure. User interfaces are usually easier to learn when they are designed to be easy to use and when they are familiar. Lee (1999) defines learnability as a dimension of usability testing whose goals and objectives are the evaluation of the degree of users' ability to operate the system to some defined level of competence after some degree of training. According to Rubin and Chisnell (2008), learnability also refers to the ability of infrequent users to relearn the system after periods of inactivity.

In this dissertation, the meaning of the learnability principle to adults is compared to the meaning of the same principle to children. The outcome of this comparison provides insights into aspects of software interfaces that adults and children approach differently. This knowledge is expected to help designers to better fulfil the needs of users of different ages. It will also contribute to the reformulation of the learnability principle in a way that distinguishes between adults and children.

1.2 Background and Motivation

According to Chiasson and Gutwin (2005), existing user interface design guidelines have historical origin in products designed for adults. Some of the design guidelines are not appropriate, in their original form, to apply to products that are designed for children. Different user age groups have different usability needs. It is therefore, appropriate to consider the adaptation of existing user interface design guidelines to suit products specifically intended for children.

Gelderblom (2008) describes these guidelines as high-level guiding principles that are widely applicable or low-level design rules that are detailed, specific and leave little room for interpretation by designers. To compile sets of general design principles for software products aimed at children, requires reformulation or adjustment in focus (Chiasson and Gutwin, 2005). There is, therefore, a need to present guidelines specifically for the design of children's technology, based on the distinctive ways in which children learn and use applications.

The choice of research was inspired by an experience l had at the UNISA usability laboratory. As part of an exploratory exercise, I brought two children aged 10 and 11 years to the usability laboratory. Some of the computers in the laboratory are loaded with a particular game-based educational software package, which the 11-year-old was well acquainted with, but the 10-year-old had not used before. I observed the 10-year-old watching closely as the 11-year-old demonstrated how the educational game was played. After a single demonstration the 10-year-old proceeded to try the game herself and did so with remarkable success, mastering all the fundamentals almost completely after just that single trial. The 10-year-old was asked to teach a 43-year-old how to play the same educational game. After observing an extensive demonstration similar to the one dispensed earlier by the 11-year-old, I observed the adult struggling to properly understand and play the game. This experience motivated me to conduct further investigations to draw a comparison between the manner in which children, aged between 9 and 12 years, and adults, aged between 35 and 50 years, learn to use a new software application.

The other reason for this choice of research was the fact that the learnability principles and guidelines for software design are generally aimed at products for adults; there is therefore a need to formulate principles and guidelines aimed at products for children. I was thus motivated by the prospect of an investigation into the differences in understanding of the meaning of the learnability principles by children and adults, resulting in the reformulation of the learnability principles.

1.3 Research Problem

The learnability principle was originally formulated in the context of computer-based applications intended for adults. There is currently a need to investigate how the same principles can be applied to applications that have been designed for children, bearing in mind that childrens' software systems are primarily designed for the purposes of play, education, and entertainment.

1.4 Research Questions

The objective of the overarching study was to compare the meaning of learnability for children and adults. The guiding question was thus:

Does learnability of software interfaces have a different meaning for children and adults?

In this regard the study investigated the following sub-questions:

- With which aspects of software interfaces do children and adults struggle?
- With what aspects of software interfaces do adults and children respectively have no problems and find engaging to do?
- What differences are there between children and adults in their emotional reaction to interface elements?
- What information does eye-tracking provide regarding differences in the behaviour of adults and children, when learning to use an unfamiliar computer game?

1.5 Study Objectives

General Objective

To compare the learning behaviours of children (aged 9 to 12 years) and adults (aged 35 to 50 years) as they learn to use a new software application.

Specific Objectives:

- To identify aspects of software interfaces with which adults and children struggle and those with which they experience no problems.
- To look for patterns in the learning behaviour of adults and children.
- To compare how children and adults learn to use unfamiliar software applications.
- To extend the learnability principle to make a variant customised for the case of children.

1.6 Research Methodology

Research Approach

In order to answer both the main research question and its sub-questions, a combination of approaches to usability testing were used. Usability testing is a technique used to evaluate a product by testing it on users. It gives direct input on how real users use the system (Nielsen, 1994). Usability testing focuses on measuring the capacity of a human-made product, for example, a web application or a computer interface, to meet its intended purpose. It measures the usability, or ease of use, of a specific object or set of objects. HCI studies attempt to formulate universal principles. Usability testing aims at determining how participants respond with respect to time, accuracy, recall and emotional response. If usability testing uncovers difficulties, such as children having difficulty understanding instructions, manipulating parts, or interpreting feedback, then developers should improve the design and test it again.

Learnability, flexibility and robustness are the principles that support usability. In this study, learnability is the only principle that is investigated, since the study is based on comparing the meaning of the learnability principle for children to the meaning of the same principle for adults. Learnability, which describes how to learn to use systems, is one of the most important and fundamental attributes of usability. The first experience most people have with a system is that of learning to use it. It is a parmount principle, in that the usability principles that directly support learnability (Familiarity, Synthesisability, Generalisability, Consistency and Predictability) are adapted from the learnability classification proposed by Dix et al. (2004). Nevertheless, the results of this study will also be useful in providing software designers with preliminary ideas on how best to eliminate design flaws that hinder users in the general use of their products.

Some tests in this study involved individual users teaching themselves. Other tests involved various combinations of pairs of users, as follows:

- an adult expert teaching a child novice,
- an adult expert teaching an adult novice,
- a child expert teaching a child novice, and
- a child expert teaching an adult novice.

Four different software applications were used, two games designed for children and two applications intended for use by adults. Where the tests involved individual users, eye-tracking data was recorded (which is not possible with more than one user at the screen). Further research methodology details are given in Chapter 3.

1.7 Significance of the Study

Of major importance were the insights that this study provided into aspects of software interfaces that adults and children experience in different ways. Such insights are vital in assisting software designers to correct or improve their products in a way that best supports the specific user group. The end result ultimately aided in the reformulation of the learnability principle in a way that distinguishes between adults and children. As a further contribution, the findings also served as foundations of evaluation criteria for software for children. Another significance of this study was that it highlighted the need to increase the granularity of the learnability principles in order to reduce mutual semantic overlap between the concepts. The way in which the learnability principles are currently defined makes it difficult to clearly distinguish one from the other. This makes it difficult to conceptualize the differences between the concepts, and to provide real-life examples that demonstrate this distinction.

1.8 Assumptions, Delimitations and Limitations

It is generally known that adults and children learn differently, but my assumption is that this has not been taken into consideration sufficiently in software design. The area of this research is HCI, with the scope being a comparative study of how children and adults learn to use an unfamiliar software application. A comparison between the learning experiences of adults and children is undertaken, using four specific software applications.

The limitation of the study is that the results cannot be generalised to all children and adults, due to both the size and composition of the sample.

1.9 Layout of Dissertation

The structure of this dissertation is given below in Table 1.1.

Table 1.1 Dissertation layout

CHAPTER	CONTENT
1. Introduction and Overview	Chapter 1 outlines the background to the main fields of study in this dissertation. A brief introduction is given, followed by background and motivation of the study. The research problem is given, explaining the approach used to understand the proposed problem. Next are the research questions, the study objectives, research methodology to be used, significance of the study and finally, delimitations and limitations.
2. Literature Review	Chapter 2 provides a comprehensive literature study. Aspects covered in the literature review include the meaning of the learnability principle for this particular study, the principles that affect learnability and the difference between learnability in children and adults. There is also a lengthy discussion on the learning theories and how people learn.
3. Research Design and Methodology	Chapter 3 describes the research design, data collection, data presentation and data analysis procedure.
4. Data Analysis and Presentation	Chapter 4 focuses on the interpretation of the data. It discusses the research results with respect to the research questions.
5. Findings Supporting the Literature Survey	Chapter 5 relates the findings discussed in Chapter 4 to the literature survey. This includes a discussion on the meaning of the learnability for children and adults and the reformulation of the learnability principle.
6. Conclusion and Recommendations	In Chapter 6, the findings from the research are summarised and conclusions are drawn. The contribution of the study is explained followed by an abridged discussion on the limitations of this study. Finally, suggestions for future research opportunities are given.

1.10 Summary

This chapter provides the background to the research and describes what drove me to embark on the study. The following chapter represents a literature review that provides the necessary theoretical background for this study, investigating relevant concepts such as the learnability principle, the learning process and learning strategies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 1 showed the need to discuss reasons why it is necessary to present principles for the design of technology specifically targeted at young children. This chapter explores what other researchers have discovered concerning the learnability principle and, more generally, how children and adults learn. A number of theoretical topics that potentially relate to the main focus of this dissertation, namely the learnability of software applications, are identified and reviewed in this chapter.

The issues that comprise the theoretical framework for this study are:

- The learnability principle.
- The differences between how children and adults learn, including their respective learning strategies.
- How adults and children acquire specific new skills.
- How the learning strategies apply to using computer software in general.
- How the learning strategies apply to the learnability principle in particular.

Some of the critical and more practical questions that Chapter 2 addresses are:

- What are the differences between learning strategies of adults and children?
- To what extent is the software learnability principle related to learning strategies?
- Which child learning strategies facilitate learnability?
- Which adult learning strategies facilitate learnability?

Since a large part of this study relies on usability experiments, I also review the literature on theoretical aspects of usability, that is, the different usability testing methods.

The rest of this chapter is organised as follows: In Section 2.2, the learnability principle and its related subprinciples are reviewed. Section 2.3 reviews the literature on adults' and children's learning process while Section 2.4 gives an overview of the specific learning strategies used by adults and children. Section 2.5 gives the conclusion to the chapter.

2.2 The Learnability Principle

2.2.1 Definitions of Learnability

Grossman, Fitzmaurice and Attar (2009) argue that there has been little consensus among researchers as to how learnability should be defined. In this section, I look at how learnability has been defined by various authors, but then base further discussions on the definition given by Dix et al. (2004) as they provide a definition applying to various forms of learning, both initial and long-term learning.

Learnability has been defined by various authors from different angles. Nielsen (1994, p.27-29) defines learnability as a novice user's first experience of learning. He insists that a learnable system could be categorised as "allowing users to reach a reasonable level of usage proficiency within a short time". Another definition (Shneiderman, 1997; Santos and Badre, 1995) explains learnabilty as the time it takes users to learn how to use the commands relevant to a set of tasks or the effort required for a typical user to be able to perform a set of tasks using an interactive system with a predefined level of proficiency. The above definitions only consider the initial learning experiences.

According to Dix et al. (2004), learnability refers to the ease with which users can enter a new system and reach a maximal level of performance. Learnability comprises specific measurable attributes (Dix et al., 2004; Senapathi, 2005) and a system's learnability can be effectively evaluated by measuring these attributes in a real life context. In the context of HCI, the learnability principle is concerned with interactive system features that assist novice users in learning quickly and also allow steady progression to expertise. The attributes are discussed in the section that follows.

2.2.2 Principles that affect Learnability

A number of principles that affect learnability have been identified by various researchers (Preece, Rogers, and Sharp, 2007; Dix et al., 2004; Senapathi, 2005; Aspinall, 2007; Kristoffersen, 2008). The study will discuss the following subprinciples that affect learnability that were originally identified by Dix et al. (2004):

- Predictability,

- Synthesisability,
- Familiarity,
- Generalisability,
- Consistency.

The learnability principles are defined in Table 2. 1 below.

Table 2.1 Principles that affect Learnability (Dix et al., 2004, p.261)

Principle	Definition	Related principles
Predictability	Support for the user to determine the effect of future action based on past interaction history.	Operation visibility
Synthesisability	Support for the user to assess the effect of past operations on the current state.	Immediate/eventual honesty
Familiarity	The extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system.	Guessability, affordance
Generalisability	Support for the user to extend knowledge of specific interaction within and across applications to other similar situations.	
Consistency	Likeness in input-output behaviour arising from similar situations or similar task objectives.	

Adherence to these principles supports learnability and makes applications simpler to use. The principles also support users in learning more effectively. Users can utilise their computer and real-world experience and transfer existing knowledge from one application, procedure, or screen to another, and also from the real-world to the computer system. The principles set out in Table 2.1 encompass elements applicable to the learning processes of adults. However, it is possible that all of these learnability principles can also be applied to products aimed at young children. The foundation assumption of the study is that the learnability principle has different meanings when applied to children and to adults. Below, I discuss the ways in which different researchers view the sub-principles of learnability with reference, where relevant, to possible differences between the meaning of learnability for children and adults. A subsection is devoted to each related principle.

2.2.2.1 Predictability

Predictability can be defined as the ease with which users can determine the result of their future interactions with the interface, based on the past interaction history (Dix et al., 2004). There are many degrees to which predictability can be satisfied. The knowledge can be restricted to the presently perceived information, so that the user need not remember anything other than what is currently observable (Dix et al., 2004). Aspinall (2007) views predictability as referring to determinism and visibility of operations. He believes system behaviour should be observably deterministic and that non-deterministic delays should be avoided. If a system is predictable, operation effects are determinable by interaction history.

Predictability is a user-centred concept which refers to the deterministic behaviour of the system from the user's perspective (Aspinall, 2007). The user ought to be able to judge what the system's response will be to the next user action, and which state it will lead to. Operation visibility is a principle that relates to predictability. It is concerned with a user's ability to envisage which operations can be performed next. Dix et al. (2004) describe operation visibility as the way in which the availability of possible next operations is shown to the user and how the user is informed that certain operations are not available. A logical consequence of this is that if an operation can be performed, then this should be clearly indicated to the user. Affordance and logical constraints should be used to indicate available actions. In Figure 2.1 below, this is illustrated by greyed-out menu options which are clearly distinguishable from the options that are available.

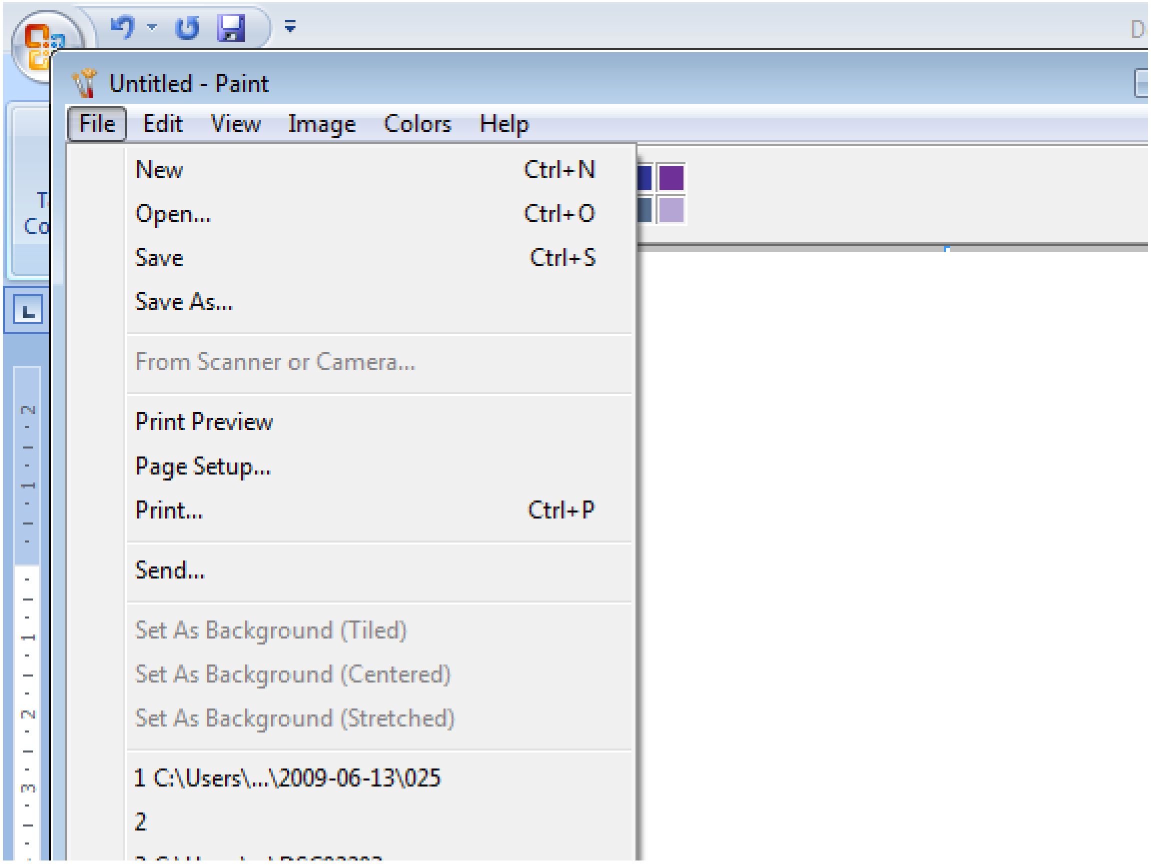


Figure 2.1 Paint interface explaining operation visibility

The predictability principle is thus very important when it comes to learning how to use an application and navigating through the available functions and activities. Like adults, if children have previously performed an action, they would expect the system to behave similarly when they perform that action again. It is important that the operations that a young user can perform next are made known through age-appropriate means. The user ought to be able to judge what the system response will be to the next user action, and which state it will lead to. Kristofferson (2008) reasons that an informal specification of this principle, as a 'theorem of usability', might be that it should be impossible to get from any state to a state that is invisible, or to apply, inadvertently, a rule which has not made itself known to the user.

2.2.2.2 Synthesisability

Synthesisability is the ability of the interactive system to provide the user with an observable and informative notification about the operation state changes within the system (Aspinall, 2007). If a system is synthesisable, the users will be able to assess the effect of past operations on the current state. The user should be able to understand which user actions have led to the current state, and what the system did to get there. There is a need to determine whether situations exist where invisible states have led to the current state. Synthesisability is therefore the criterion representing the inverse of predictability.

Two aspects of synthesisability are immediate honesty and eventual honesty (Dix et al., 2004). Honesty refers to the ability of the user interface to provide an observable and informative account of any change an operation makes to the internal state of the system. Honesty is immediate when the notification requires no further interaction by the user. It is eventual when the user has to issue explicit directives to make the changes observable (Dix et al., 2004). Direct manipulation interfaces promise immediate honesty (Aspinall, 2007).

Command line interfaces are never honest, as illustrated in Figure 2. 2 below.

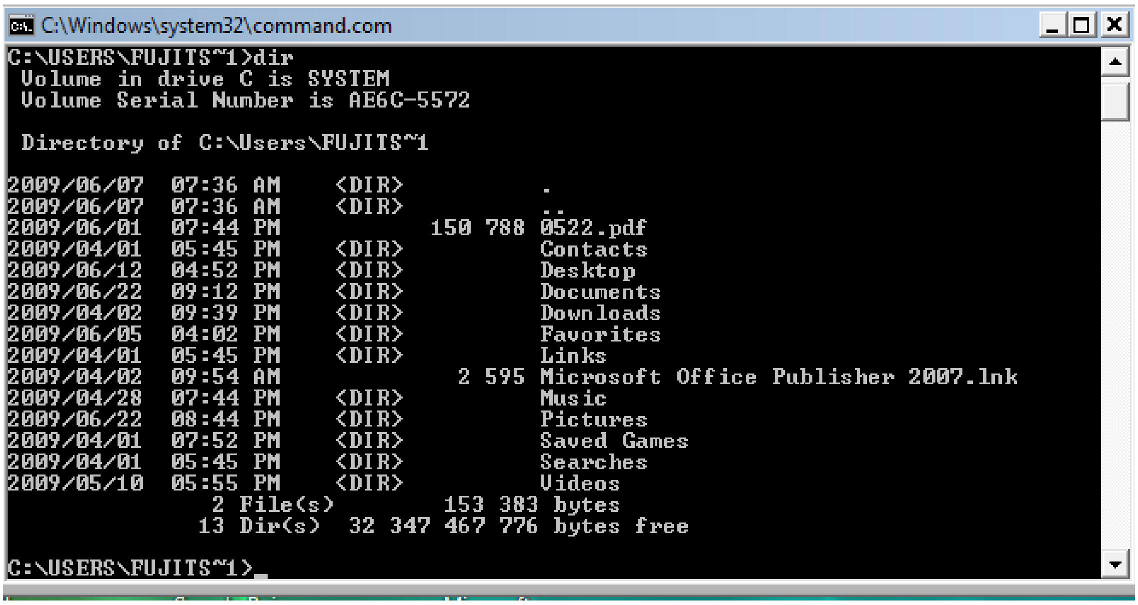


Figure 2.2 Command line interface with low honesty

The interface does not show, for example, what has happened to the listed files in past operations. In order to see changes, one must list individual directories. For example, if a file has previously been deleted from one of the folders, one cannot tell from which folder that file was deleted by just observing the command line window. But if one had information on how many files the Pictures folder had beforehand, then, when one observes an increase in the available memory, one would have to open the Pictures folder to conclude that the increase in the available memory resulted from the deletion of a file from the Pictures folder.

Children tend to keep selecting the print option with the hope that it will eventually print when performing a printing operation and the printer does not respond. This is an example of the importance of synthesisability for children's products. The system should immediately provide age-appropriate feedback telling the child that the print document is in a queue, so that they do not keep sending the print document (Gelderblom, 2008). For the novice user not familiar with the system's operations, synthesising the consequences of the operations carried out by the system may be more difficult. When a system is synthesisable, users can assess the consequences of their actions. Changes should be visible, or acknowledged. For example, deleting a file makes the icon disappear, or gives a 'file deleted' message.

2.2.2.3 Familiarity

The familiarity principle is concerned with the ability of an interactive system to allow a user to map prior experiences, either real-world or gained from interaction with other systems, onto the features of a new system (Dix et al., 2004). This is an externally oriented criterion, which captures the extent to which the user experiences a real-world parallel to the system. Familiarity attempts to measure the correlation of users' knowledge with the skills needed for effective interaction. According to Grudin (1989), familiarity can be summarised as the extent to which functionality offered by the system is similar to 'a priori' or at least widely-held experiences. It overlaps nicely with Grudin's third consistency definition, namely correspondence of interface features to familiar features of the world beyond computing.

Familiarity is the extent to which children and adults' prior knowledge can be applied in learning to use a new application. For example, a recycle bin is a familiar item in most parts of the western world. Most children and adults are familiar with the bin which they use to dispose of rubbish. The concept of familiarity matches users' expectations and relates to how their prior knowledge applies to a new system. This is referred to as the guessability of features in the system. The way that an object appears, stimulates a familiarity with its behaviour or function (Gelderblom, 2008). For example, the objects on the screen which denote buttons should have a three-dimensional appearance

(Aspinall, 2007) so that they look like buttons. However, what is familiar to adults is not necessarily familiar to children. Children may have limited world experience, while adults are more familiar with the use of metaphors.

2.2.2.4 Generalisability

Generalisability is the interactive design principle that provides support for users to extend knowledge of specific interaction within and across applications, to new, but similar, situations (Dix et al., 2004). Aspinall (2007) defines generalisability as extending specific interaction knowledge to new environments. Generalisability is sometimes described as ‘a form of consistency’, except that it applies more broadly to situations, rather than just to operations. It is a state where existing knowledge can be successfully applied. This is the extent to which related functionality can be grouped, or a sequence of actions can be seen as coming to some form of ‘closure’ (Aspinall, 2007). Generalisability helps to give a predictive model of a system for the user and a form of consistency. User interface standards and guidelines promote generalisability. For example, applications should offer the Cut/Copy/Paste operations wherever possible and implement them in the standard way, using the standard icons and key combinations. Similarly, a user knowing how to draw a rectangle using a drawing package should be able to apply this knowledge to draw a circle using a different package.

2.2.2.5 Consistency

To support generalisability, consistency is essential. The system should offer the same or similar functionality in comparable situations, and in a familiar fashion. The same or similar actions should yield the same response. This means that the same or similar components are expected to look alike and to respond similarly on user input. It is the extent to which similar appearances offer the same functionality. Consistency is the most widely discussed usability principle in the literature (Dix et al., 2004). Consistent interfaces are easier to learn and use (Preece, Rogers and Sharp, 2007). They assist the user in gaining more confidence in using the system and encourage them to try out exploratory learning strategies (Nielsen, 1993).

Consistency between applications is always advantageous; however, consistency within an application is essential. The use of labels and icons should always be consistent. The same icons and labels should mean the same things. The principle of 'sameness' should be applied to the use of terminology, formatting and input/output behaviour arising from similar situations or task objectives (Preece, Rogers and Sharp, 2007). Standard Graphical User Interface (GUI) design factors such as consistent patterns in layout, same short-cut keys for similar actions, and same placement for recurrent menu options, should aid designers in taking consistency into account at every level of design (Aspinall, 2007).

2.2.3 Summary

A system is easy to learn when it is predictable. Users are sure of what happens next and what they are allowed to do next. Users can assess the consequences of their actions when the system is synthesisable. When the system is familiar, the user will relate it to similar real-world situations or systems. When the system is generalisable, users will be able to use what they have already learnt to carry out new tasks. Ensuring consistency is the most important guideline, but the most frequently violated. Consistency means the system will behave in the same way when comparable sequences of actions take place in similar situations.

In summary, learnability deals with initial understanding of the system by the novice user as well as the attainment of maximum performance once they have learned how to use it. Based on other real-world or computer systems, novice users of a software application should be able to experience some level of familiarity with the system. The application has to be general enough with respect to other applications and situations to allow the user to apply the interaction techniques from similar situations. The applications must be predictable and show the effect of future interactions based on the previous interactions and they must be synthesisable to allow the user to assess those future effects, based on the current state of the system when there is no history of previous interactions. Above all, there must be considerable consistency within the system and with respect to other systems. The preceeding discussion clearly indicates that the principles are not mutually exclusive, but rather, they are interrelated.

This completes the discussion on the principles that affect learnability. In the next section, I will discuss the learning process in general and the acquisition of specific skills.

2.3 The Learning Process

The study focuses on the comparison of learning of a software application by adults and children. Learning is a central process in how children and adults master the different computer programmes. The term ‘learning’ relates to a highly complex and multi-faceted concept which is used in several different ways. Various authors propose different views regarding what they consider to be the definition of learning and some of the definitions are given below.

2.3.1 Definition of Human Learning

According to Jarvis (1987; as cited by Long, 1990), learning is regarded as the process of transforming experience, skills and attitudes. It is important to note that learning involves a number of different sub-processes and it occurs in varying situations. Learning is broader than education and can occur outside of the educational institution (Long, 1990). It includes a wide range of behaviours characterised by the active process of acquiring new knowledge and skills, as well as creating new connections between existing knowledge and skills. Learning occurs in informal everyday contexts as well as in structured learning situations, and involves associations or relationships between and among elements (Ramey and Ramey, 2004). Driscoll (2000, p.11) refers to learning as “a persisting change in human performance or potential”. By this he means that learners are capable of doing something in which they would have failed before the learning occurred.

According to Roschelle et al. (2001), cognitive research has shown that learning is most effective when four fundamental characteristics, namely active engagement, participation in groups, frequent interaction and feedback, and connections to real-world contexts, are present.

With regard to active engagement, learning research has shown that learners learn best by actively ‘constructing’ knowledge from a combination of experience, interpretation, and structured interactions with peers and teachers. When learners are placed in the relatively passive role of receiving information from lectures and texts (the ‘transmission’ model of learning), they often fail to develop sufficient understanding to be able to apply what they have learned to situations outside their texts and classrooms (Roschelle et al., 2001).

As for participation in groups, Roschelle et al. (2001) argue that social contexts give learners the opportunity to successfully apply more complex skills than they could execute alone. Performing a task with others provides opportunities not only to imitate what others are doing, but also to discuss the task and make thinking visible. Much learning is about the meaning and correct usage of ideas, symbols, and representations.

In learning through conventional instruction and feedback, in traditional classrooms, learners typically have very little time to interact with materials, each other, or the teacher. Research suggests that learning proceeds most rapidly when learners have frequent opportunities to apply the ideas they are learning, and when feedback on the success or failure of an idea comes almost immediately.

One of the core themes of current learning research, has been the frequent failure of learners to apply what they learn in school to problems they encounter in the real world, that is, learning is not contextualised (Illeris, 2006). Learning can refer to the mental processes that take place in an individual that lead to the changes or outcomes of learning processes (Illeris, 2006). It can also refer to the interaction processes between individuals and their material, and their social environment. The interaction processes include action, communication and cooperation and are preconditions for the inner learning processes, which should impact on situations encountered in the external environment.

Quam (1998) regards learning as a change in human disposition or capability which can be retained. He believes it is an experience which occurs in a person and is activated by the person. Learning is the discovery of personal meaning and worth of ideas. It is a change in insights, behaviours, perceptions, or motivation, or can be a combination of all of these. It can also be regarded as a consequence of experience. Learning results in certain kinds of changes, the most common being the committing of facts to memory, the acquisition or improvement of a skill or process, and the development of a changed attitude.

Human learning is a process whereby a person moves from not knowing something to knowing something. It can be deliberate or incidental, it can be cognitive or practical, but it involves change with regard to knowledge, skills or attitudes (Jarvis, 2006).

Jarvis (2006, p.13) defines human learning as "the combination of processes whereby the whole person – body (genetic, physical and biological) and mind (knowledge, skills, attitudes, values, emotions, beliefs and senses) – experiences a social situation, the perceived content of which is then transformed cognitively, emotively or practically (or through any combination) and integrated into the person's individual biography resulting in a changed or more experienced person". According to Burns (1995), learning is a relatively permanent change in behaviour, where behaviour includes both observable activity and internal processes such as thinking, attitudes and emotions.

Rushton, Eitelgeorge and Zickafoose (2003), suggest that learners of all ages attempt to make sense of the world around them and their experiences by synthesizing the present moment, skill, or concept being taught with their own prior knowledge, conditions of learning, and mental understandings. Young children, in particular, generate internal rules or schemas to better understand and connect what they are experiencing, or being taught, to what they have learned previously. Constructivists believe that the learner generates or constructs a personal understanding of the environment through a process of interaction, reflection, and action. This will be discussed in detail in later sections.

According to Goffree and Stroomberg (1989) learning entails some elements of risk because one does not always know exactly where one will end up. It must be possible to adjust our learning along the way. Learning often involves a certain personal intention where individuals have something definite in mind when learning. In other words, learning is future-oriented. Learning also involves making choices where the activity structure is flexible and involves different possible situations. It is also concerned with creating or constructing new possibilities. Goffree and Stroomberg (1989) sum up learning as a wholehearted, purposeful activity in a social, interactive environment.

2.3.2 Learning as a Cyclic Process

Kolb's model is one of the most widely known tools for describing the learning process and determining an individual's learning preferences (Holmes, 2003; McGill and Beaty, 1995). Kolb proposed a four-stage learning process that structures learning as occurring through places of concrete experience (activity), observation and reflection (reflection), abstract conceptualization (theory) and through active experimentation (pragmatism). The process is represented in cyclic form, showing that it can begin at any of the stages, and is continuous. Kolb's model, as shown in Figure 2.3, is a model of experiential learning (Houle, 1980).

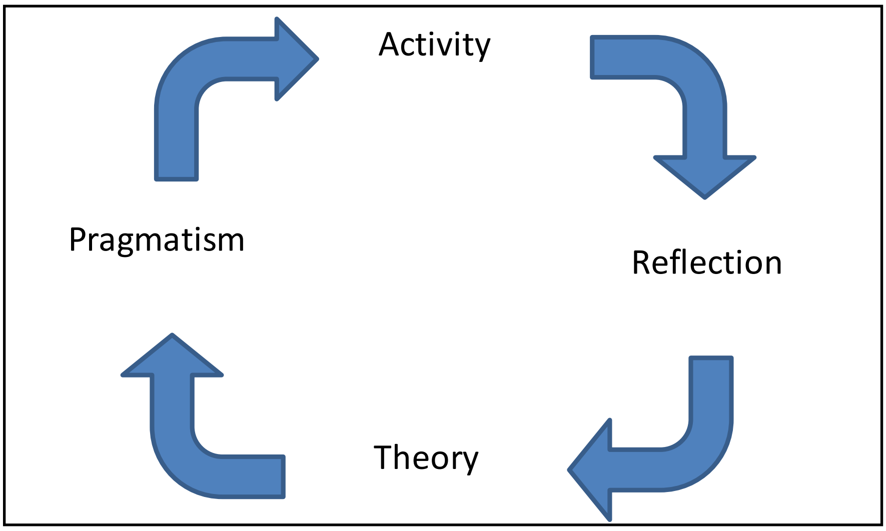


Figure 2.3 Kolb's model (Holmes, 2003)

There is a variety of components within learning. *Activity* is about doing something and is associated with people who prefer to act rather than think in a learning process (Roger, 2007). People who prefer to learn in a real-world setting rather than a classroom (Holmes, 2003). *Reflection* involves thinking about the experience and is associated with people who prefer to consider the advantages and disadvantages of doing things. Such people prefer to learn through observation and from other people. *Theory* involves seeing where the learning fits in with theoretical ideas and refers to people who learn through abstract thinking and modeling rather than taking action (Holmes, 2003). *Pragmatism* entails applying the learning to actual problems and can refer to people who learn best by tackling a practical problem. Although people's preferred styles determine at which stage of the cycle they will start, Kolb's idea is that they still go through all the stages. There is no limit to the number of cycles one can make within a learning situation.

In clarifying the application of the above-mentioned four-stage learning process, Smith (2001) suggests that learning often begins with a person carrying out a particular action and observing the effect of the action in the particular situation *(activity)*. The proceeding step is then to understand these effects in the particular instance so that, if the same action were taken in the same circumstances, it would be possible to anticipate what would follow from the action *(reflection)*. In this pattern the third step would be to understand the general principle under which the particular instance falls *(theory)*. When the general principle is understood, the last step involves application through action in a new circumstance within the range of generalisation *(pragmatism)*. In reality, if learning has taken place the process could be seen as a spiral with the learner being able to repeat the action and anticipate the possible effects under different circumstances

Quam (1998) also views learning as a cyclic process. He distinguishes between three types of learning: cognitive, effective and psychomotor. The outcome of cognitive learning is thinking skills, which also includes acquiring verbal information to learn facts and concepts and intellectual learning for knowledge. The outcomes of effective learning are attitudes, beliefs and values, while the outcome of psychomotor learning is the acquisition of skills to perform tasks.

2.3.3 Learning Theories

Siemens (2006) is of the opinion that a learning theory is an attempt to describe how people learn and to provide vocabulary and a conceptual framework for interpreting the examples of learning that we observe. Learning theories seek to provide insight into the act of learning. Behaviourism, cognitivism and constructivism are the three main categories under which learning theories fall. According to Alessi and Trollip (2001) and Xiangui (2005), learning theory, in the mid-twentieth century, was dominated by principles of behavioural psychology, which was exemplified by the work of Skinner (1974, 1957, 1938). It maintained that learning should be described as changes in observable behaviour of a learner made as a function of events in the environment. Later in the 1970s, the behavioural paradigm began to be expanded by the ideas of cognitive psychology, which maintained that a complete explanation of human learning required recourses to nonobservable constructs, such as memory and motivation. A new learning paradigm, constructivism emerged in the 1980s. It maintained that only an individual's interpretation of the world matters and that everyone constructs their own view of reality (Alessi and Trollip, 2001). Each of these three theories is equally important and can be used in accordance with the level of knowledge of the learners and the cognitive processing demands. Each will now be discussed in more detail.

2.3.3.1 Behaviourist Learning

Behaviourists see learning as occurring through the observation of behaviour in a black box (Driscoll, 2000). Behaviourism is a worldview that assumes a learner is essentially passive, responding to environmental stimuli. The learner starts off as a clean slate (i.e. *tabula rasa*) and behaviour is shaped through positive reinforcement or negative reinforcement. Both positive reinforcement and negative reinforcement increase the probability that the antecedent behaviour will happen again. In contrast, *punishment* (both positive and negative) decreases the likelihood that the antecedent behaviour will happen again. 'Positive' indicates the application of a stimulus whilst 'negative' indicates the withholding of a stimulus. Learning is therefore defined as a change in behaviour in the learner. A lot of early behaviourist work was done with animals (e.g. Pavlov's dogs) and was generalised to humans. Behaviourists are largely concerned with the outcome, or observable elements, of learning.

Behaviourism is influenced by the nature of reward and punishment stimuli. Instead of focusing on the internal mental activities, behaviourists focus on observable behaviour. Behaviour is managed through a process of strengthening and weakening of responses. Behaviourism precedes the cognitivist worldview. According to Gredler (1997), behaviourism rejects structuralism and is an extension of Logical Positivism. Key theorists in behaviourism include: Pavlov, Watson, Skinner, and Thorndike, with Skinner developing radical behaviourism (Gredler, 1997). It is distinct from other schools of behaviourism, with major differences in the acceptance of mediating structures, the role of emotions and others.

2.3.3.2 Cognitive Learning

Cognitivism relates to the results of cognitive processes such as the formation of mental models, human information processing, metacognition, and self-regulation. Cognitivists see learning as information-processing done internally (Driscoll, 2000). Many of the information-processing models of teaching and learning are based on the cognitive view of learning. Learning should support cognition, retention, and transfer. New knowledge should be integrated with prior learning, building new skills on previous knowledge. Cognitive processes are seen as being as important as generating learning products. Cognitive learning aims to foster critical thinking skills by authentic problem-solving or by explicit teaching of cognitive strategies alongside content knowledge

(Alessi and Trollip, 2001). Cognitive theory is a learning theory of psychology that attempts to explain human behaviour by understanding the thought processes. The assumption is that humans are logical beings that make the choices that make the most sense to them. 'Information-processing' is a commonly used description of the mental process, comparing the human mind to a computer.

Pure cognitive theory largely rejects behaviourism on the basis that behaviourism reduces complex human behaviour to simple cause and effect (Fritscher, 2009). However, the trend in past decades has been towards merging the two into a comprehensive cognitive-behavioural theory. Social cognitive theory is a subset of cognitive theory. Primarily focused on the ways in which we learn to model the behaviour of others, social cognitive theory can be seen in advertising campaigns and peer pressure situations (Fritscher, 2009).

2.3.3.3 Constructivist Learning

According to De Villiers (2005, p. 359), "constructivism relates to personal knowledge construction and interpretation, active learning, anchored instruction, and multiple perspectives on an issue". Constructivists hold learning to be a process of active construction on the part of the learner. Learning occurs as learners "attempt to make sense of their experiences" (Driscoll, 2000, p. 376). The roots of constructivism can be found in the epistemological orientation of rationalism, where knowledge representations do not need to correspond with external reality (Driscoll, 2000, p. 377). Adherents to constructivism borrow heavily from theorists like Piaget, Vygotsky, and Bruner (Driscoll, 2000).

According to De Villiers (2005, p.359), Constructivism "aims to instil personal goals and active involvement within real-world situated learning, leading to application skills and transfer". It emphasizes collaborative activities and learner-research using a wide variety of resources. The constructivist approach is based on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Thus, individuals use their own mental constructs to make sense of their experiences.

von Glasersfeld (1989, p.162-163) gives the following basic principles of constructivism:

- Learning is a search for *meaning*. Therefore, learning must be based on the issues that require personal interpretation.
- The construction of meaning requires an understanding of '*wholes'* (the bigger picture) as well as *parts*, and parts must be understood in the *context* of wholes. Therefore, the learning process focuses on primary concepts, not on isolated facts.
- Emphasis is placed on the application of knowledge as opposed to a mere acquisition of decontextualised facts.
- *Social aspects* of learning form a crucial part of the constructivist view of learning. This means that people also learn from one another and not only in isolation from others.

It is argued that the responsibility of learning should reside increasingly with the learner (von Glasersfeld, 1989). The theory of social constructivism emphasizes the importance of the learner being actively involved in the learning process. It suggests that learners construct and interpret knowledge out of their personal experiences. von Glasersfeld (1989) emphasizes that learners construct their own understanding and that they do not merely mirror and reflect what they read. Learners look for meaning and will try to find regularity and order in the events of the world, even in the absence of full or complete information.

2.3.3.4 Comparison between Behaviourist, Cognitive and Constructivist Learning

I briefly distinguish between the behaviourist view, the cognitive view and the constructivist view of learning. Behaviourism focuses only on the objectively observable aspects of learning, while cognitive theories look beyond behaviour to explain the mental processes involved in learning and constructivism views learning as a process in which the learner actively constructs or builds new ideas or concepts. According to a behaviouristic view of learning, a learning result is indicated by a change in the behaviour of a learner (Venezky and Osin, 1991). According to a constructivist view, learning is seen as the individualized construction of meanings by the learner (Cunningham, 1991; Duffy and Jonassen, 1991). According to Alessi and Trollip (2001) constructivist educators maintain that the behavioural and cognitivist paradigms treated the learner as a bucket into which knowledge about the world was poured by teachers, books and instructional media. In contrast, constructivism views learners as active creators of knowledge, who learn by observing, manipulating, and interpreting the world around them. None of these views can be regarded as exclusively right or wrong. It is, however, necessary to know that constructivism is presently accepted as the more relevant of the three and that education policies, education models and education practices focus on constructivist learning. Table 2.2 below summarises the differences between the approaches.

Table 2.2 Learning Theories (Adapted from Siemens, 2006 by Jones, 2009, p.2)

Property	**Behaviourism**	**Cognitivism**	**Constructivism**
How does learning occur?	Black box observable behaviour main focus	Structured, computational	Social, meaning created by each learner (personal)
Influencing factors	Nature of reward, punishment, stimuli	Existing schema, previous experiences	Engagement, participation, collaboration, social, cultural
What is the role of memory?	Memory is the hardwiring of repeated experiences where reward and punishment are most influential	Encoding, storage, retrieval	Prior knowledge remixed to current context
How does transfer occur?	Stimulus, response	Duplicating knowledge constructs of "knower"	Socialization
Types of learning best explained	Task-based learning	Reasoning, clear objectives, problem solving	Social, vague ("ill defined")

When deciding which strategies to use, it is vital to consider both the level of knowledge of the target group of learners and the cognitive processing demands. The educator should consider the nature of the learning task, the level of cognitive processing required to perform it, and the proficiency level of the learners. Some theoretical strategies overlap in the level of cognitive processing required and this should be taken into account. Strategies from varying theoretical perspectives should be applied as needed.

2.3.3.5 Summary

In this section an overview of learning in general was discussed, based on views by various authors and theories of learning. Points emerging from this discussion are the following:

- Mental processes that occur within an individual lead to internal or external changes and result in the outcomes of learning processes.
- Interaction processes between individuals and material, between learners and their social environment, are preconditions for the learning processes.
- Learning is deliberate or incidental and can be cognitive or practical, but, whichever form it is, it involves change with regard to knowledge, skills and/or attitudes.
- Learning is a combination of processes which the whole person experiences in a social situation.

According to Kolb's model, the learning process can be described as a cyclic process that can be commenced at any point. Furthermore, learning can be enhanced by the development of specific skills, which is discussed next.

2.3.4 Skills Development

Once an individual has developed foundations on which learning is constructed, they can then progress to obtain skills that support or enhance what has been learnt. According to Lawther (1977), the skills acquisition stage is reached when the individual has acquired the capacity for learning founded on past practice and experience. Skills are of three types: first are *psycho-motor* skills, which are skills that a person has performed repeatedly and which have become instinctive, e.g. tying shoelaces, riding a bicycle and playing games on the computer. At first, the learner has to concentrate intently on the steps, but later he/she does it automatically. For Cotton (1995), psychomotor skills are physical actions in which the processes involved are primarily muscular. Next are *perceptual* skills that are controlled, practised, precise and accurate and are carried out by the senses. Examples of perceptual motor skills include hand-eye coordination, body-eye coordination, auditory language skills, postural adjustment, and visual-auditory skills (Piley, 2010). Young children can practice perceptual motor skills through active play, object manipulation, drawing, blocks, and various other forms of physical activity. In all behaviours the cues for action and the checks for correct performance need trained perceptual skills. Finally, there are *cognitive* skills that are used in the process of acquiring knowledge. These skills include reasoning, perception, and intuition (Cotton, 1995). Acquiring these skills involves learning to do something at a high level of performance.

Skills are developed through repetition of an activity, leading to the development of expertise. Jarvis (2006) believes a skill is learnt through the act of doing and this results in experience. As a skill develops, simple activities become relatively automatic and may then be combined into larger and more complex activities. Children love to see how a new skill can be used in different ways. They often repeat favourite stories, games or songs. Ramey and Ramey (2004) call it brain chemistry at work. In this process of repetition, certain pathways that link positive emotional states to increasing comfort with a repeated task or experience will be activated and strengthened. Parents or adults can help children develop their skills, be they academic or social, by encouraging them to keep journals, to write and to draw.

According to Vagenshtein (2008), the constructivist approach views the learner as an active participant in the construction of autogenic knowledge, based on a process of interaction with the environment. According to constructivism, learning takes place as an active process in which the learner constructs and incorporates new ideas or concepts into his consciousness on the basis of an existing cognitive structure. Hands-on activities are the best for the classroom applications of constructivism, critical thinking and learning. Having daily observations recorded in journal helps the students to better understand how their own experiences contribute to the formation of their theories and observational notes, and then comparing them to another students' concepts reiterates that different backgrounds and cultures create different outlooks. While neither is wrong, both should be respected.

Gelderblom (2008) describes how the development of skills can be supported. A range of activities should be provided that allow children to build up their reasoning skills through interactive exploration and manipulation of different kinds of representations. In adults, skills are developed more effectively in cases where the learner understands why he has to learn and develop a skill. The learner is supposed to know the role and importance of that skill in his life. Learning and developing a skill produces significant effects if the practice of that skill is carried out under real-life conditions and in real settings. For skill development to occur, users should acquaint themselves with the relevant equipment and facilities. They should use established techniques that have been proved successful.

In the following section I shall discuss findings from the literature regarding the ways in which children and adults learn.

2.3.5 How Adults Learn

Extensive research on adult learning has been conducted from different perspectives and various suggestions have been made. Malcolm S. Knowles is regarded as one of the world's leading scholar-practitioners of adult learning (Brookfield, 1995). His early understanding of the importance of adult learning provided insight that has guided professions dedicated to adult learning. However, despite the many journals, books and research conferences written on adult learning worldwide, there is not yet a universal understanding of adult learning (Brookfield, 1995).

Learning is a fundamental process underlying human development (Merriam, Caffarella and Baumgartner, 2007). Adult learning takes place between two extremes which can be distinguished in the learning process. The one extreme is incidental or unconscious learning which occurs according to processes over which one has little control. The other extreme is represented by carefully chosen and purposeful learning activities that demand a great deal of effort and perseverance (Goffree and Stroomberg, 1989).

Knowles (1998) says that in the field of adult learning theory, also referred to as andragogy, many factors affect the ways in which adults learn. A person is driven to learning by the desire to know more. In order to motivate an adult, whatever they learn must be relevant to their everyday lives. Gravett (2001) says adults enter learning with a large quantity of experience that varies from individual to individual. She refers to other research Houle (1980; as cited by Gravett, 2001) that identified three main orientations of adults, namely:

1. Adult learners who are activity-orientated. These learners pursue learning activities out of social or personal growth needs, and they satisfy their needs in undertaking the activities.

2. Adults who require further education in order to get a promotion or a qualification or to solve an immediate problem facing them.
3. Adults who are intrinsically learning-orientated and seek knowledge or skill for its own sake because it interests them.

The orientation of interest in this study is the first category in which an adult pursues learning for the sake of social and personal growth needs. That is the most common orientation that drives adult learners, because it satisfies their needs.

An adult’s ability and willingness to learn is largely affected by the value they place on the task at hand (Knowles, 1998). There is a form of competitiveness in the way adults approach learning. For adults, learning is linked to quality of life and self-esteem. They judge themselves according to how learned they are. Illeris (2006) agrees with Knowles when he states that adults learn what they want to learn and what is meaningful for them to learn. In their learning, they draw on the resources they already have. Adults also take major responsibility for their learning and are not very inclined to engage in learning of which they cannot see the meaning or in which they are not interested. Adults who have decided to learn something, generally wish to see immediate results of their efforts.

According to Brookfield (1995), openness to learning is based on the individual’s personal situation, with their environment affecting their learning ability. Factors such as background and work experience determine the starting point of learning, thus it cannot be assumed that all adults will commence study at the same level. It should also be taken into account that people see themselves differently from others, with some adults placing greater importance on study than others. The less satisfied they feel with their station in life, the more likely they are to approach learning in a positive light, as a means to attain more in terms of job satisfaction and individual self-worth.

Adults use self-directed learning to learn. Self-directed learning focuses on the process by which adults take control of their own learning, in particular how they set their own learning goals, locate appropriate resources, decide on which learning methods to use and evaluate their progress (Brookfield, 1995).

According to Leberman, Mcdonald, and Doyle (2006), numerous appraisals of Knowles's (1998) work have been undertaken and various theorists have built further on his ideas about adult learners and adult learning. These theorists tend to agree that effective learning and teaching practices apply to all learning and are not specific to adult learning, but that the degree and the frequency of these may be more marked in adult learning (Leberman, Mcdonald, and Doyle, 2006). Some of the common characteristics of adult learners identified by Leberman, Mcdonald, and Doyle, (2006, p.131) are:

- The tendency with maturation to move from being other-directed to being *self-directed;*
- With ageing, a wealth of *prior experiences* and learning is acquired which may be a rich source for learning;
- An individual's experiences become crucial to their *sense of self* as they age;
- An individual's *readiness to learn* is linked closely to their social roles;
- As an individual ages, his perspective on time shifts from one with a future orientation to one which emphasises *immediate application*;
- As individuals mature, they tend to prefer *problem-centred* learning rather than theoretical or content-centred learning.

Although there are certain common learning traits among learners, Knowles (1998) argues that adults display characteristics quite different from those of children. Section 2.3.8 elaborates on these specific differences.

2.3.6 Adult Learning Characteristics

The characteristics of adult learning are multiple and inter-related, although they all relate to a process of discovering something new (Merriam, Caffarella and Baumgartner, 2007). When adults set out to learn a new software system, they usually do so voluntarily (Ference and Vockell, 1994). Ference and Vockell identified learning characteristics specifically associated with learning to use software. These learning characteristics are displayed differently in each learner. For learning to be effective, every characteristic listed must be recognized. The characteristics are explained in Table 2.3 below.

Table 2.3 Adult learning characteristics in learning to use software (Ference and Vockell, 1994, p.25)

Characteristics	Explanations
1. Active-learner	Provided with opportunities and proper incentive, adult learners willingly engage actively in the learning process. They do not feel comfortable being passive learners.
2. Experience-based	Learning is dependent on prior knowledge. Adult learners bring a wide variety of prior educational and life experiences to a new learning situation.
3. Expert	Adult learners can be classified as experts in many fields. Real-life experiences have contributed to their vast areas of expertise.
4. Independent	Adult learners are able to depend on themselves to accomplish things. They tend to draw and rely on their personal experience and knowledge to seek answers to questions and to solve them.
5. Hands-on	Adult learners have often acquired their most successful skills through concrete, hands-on experience. They prefer to continue this practice of learning by doing rather than by listening.
6. Life-centred	Adult learners are typically faced with important matters in everyday life. As a result, the adult learner tends to focus attention on real-world situations.
7. Task-centred	Adult learners are typically more active in performing tasks directed toward reaching a goal or solving a problem.
8. Problem-centred	Adult learners are more focused on dealing with problems they encounter in their particular life situation.
9. Solution-driven	Adult learners operate in the real world, focus on real-life problems, and often actively seek out solutions to their problems.
10. Value-driven	Adult learners need to know why they should learn something before undertaking to learn it. Given the rationale for learning something, they will often invest considerable energy in investigating the increased benefits to be gained from the learning experience and the consequences of not learning it.
11. Skill-seeking	Adult learners often actively seek out the attainment of new and improved skills in order to better meet and solve real-life problems.
12. Self-directing	Adult learners usually perceive themselves to be independent and responsible for their own actions and need to be directly involved in planning and directing their learning activities.
13. Motivation (External)	Adult learners are often externally motivated by factors such as better jobs, increased promotional opportunities, and higher salaries.
14. Motivation (Internal)	Adult learners are often internally motivated by factors such as self-esteem, recognition, confidence, career satisfaction, and the overall quality of life.

The discussions by Knowles and other authors on adult learning given in Section 2.3.5, correspond with Ference and Vockel's (1994) learning characteristics associated with learning to use software.

This section and the previous section explored literature that described findings from research on how adults learn. The discussion provides an overview on why adults want to learn and how they learn. To summarize, one can conclude that the characteristics of adult learners include independence, a background of prior experience, a natural orientation towards learning, and strong internal motivation.

Next, it is important to discuss how children learn, in order to be able to compare the ways in which adults and children learn.

2.3.7 How Children Learn

Children learn best when the learning is self-initiated, arising from their own curiosity, inquisitiveness, and interests, rather than when it is imposed on them (Woolley, 1997). Children engage in different types of learning. These forms of learning can occur in, and be applied to, many areas including creativity, social relationships, imaginative and fantasy play and other forms of adaptive behaviour. Woolley (1997) suggests that children tend to live in a world in which fantasy and reality are closely related, a world where animals talk like people, fish can fly, and wishes come true. Piaget (1924, 1930, as cited by Woolley, 1997) held that children not only confuse fantasy and reality, but also the mental and the physical, dreams and reality, and appearance and reality.

2.3.7.1 Learning through Discovery

Solter (1992) believes that learning requires the active, constructive involvement of the learner. Children learn through hands-on experiences and self-discovery, rather than through direct instruction (Ramey and Ramey, 2004). This reflects the constructivist approach to learning, which emphasizes learning and not teaching, encourages and accepts learner autonomy and initiative, sees learners as creatures of will and purpose, thinks of learning as a process, encourages learner inquiry, and acknowledges the critical role of experience in learning. According to van Joolingen (1999, p.385), "discovery learning is a type of learning where learners construct their own knowledge by experimenting with a domain, and inferring rules from the results of these experiments. The basic idea of this kind of learning is that because learners can design their own experiments in the domain and infer the rules of the domain themselves they are actually constructing their knowledge. Because of these constructive activities, it is assumed they will understand the domain at a higher level than when the necessary information is just presented by a teacher or an expository learning environment".

In this kind of learning, children are left to make their own inferences, discoveries, and conclusions. Sometimes learners learn the new information that is presented to them by building upon knowledge that they already possess. It is learning that takes place in problem-solving situations where the learner draws on his own experience and prior knowledge. Furthermore, it is a method of instruction through which children interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. As a result, children are more likely to remember concepts and knowledge which they have discovered on their own. Ramey and Ramey (2004) argue that there is a great deal of scientific evidence about the importance of children's own actions in learning. When a child initiates an activity or is actively engaged, they typically learn more. Ramey and Ramey (2004) use the term 'contingent learning' for the activities in which a child learns that certain actions or words produce predictable results.

2.3.7.2 Cause-and-Effect

According to Ramey and Ramey (2004), another kind of learning involves the discovery of cause-and-effect relationships. This form of learning is based on children's observations and experiments with things and people. Children naturally seek to make sense of their experiences and to find order and reliable patterns in what happens around them. It is also important for children to learn which of their behaviours produce desirable effects and to eliminate those that do not (Ramey and Ramey, 2004). This cause-and-effect learning is the foundation for much of what happens when children are still very young. They can manipulate objects, solve problems, and observe orderly patterns and variations. As children get older, cause-and-effect relationships contribute to their understanding of probability, that is, that some things are more or less likely to occur under certain conditions. Children's natural curiosity should be encouraged in many ways (Ramey and Ramey, 2004).

2.3.7.3 Learning through Imitation

According to Vagenshtein (2008), the most widely used learning channel is that of observation and imitation. At the heart of this approach lies imitative ability that is, the learner sees someone, a ‘model’, perform an action, and he imitates this action, reconstructing it on his own. Vagenshtein cites Bandura (1963), who says that learning through observation and imitation has three main components:

Attention – the learner has to be aware of, and focused on, the specific behaviour of the model;

Memory – since the learner does not carry out the modelled activity right away, he has to store it in his memory and retrieve it later on for emulation;

Ability – the learner has to be capable of performing the activity carried out by the model.

Children learn through this type of learning when they observe adults, especially their parents or guardians, and imitate them. Thornton (2002) points out that children are keen observers of other people and can be wonderful mimics. The drive to learn from observing and imitating others, may be a basic element of their genetic inheritance. A great many of the everyday skills and assumptions acquired in childhood are the direct product of imitating those in their immediate environments. Imitation and observation are social processes affecting cognitive development (Thornton, 2002).

Vygotsky (1978) identifies the convergence of speech and practical activity as important elements of the learning process. The author suggests that a child constructs intrapersonal meaning through practical activity, while speech is used in interpersonal communication to connect this meaning with the interpersonal context of the child.

2.3.7.4 Concept Formation

Formation of concepts is a type of learning that originates from infancy and becomes increasingly complex and apparent as the infant grows into a child. Ramey and Ramey (2004) acknowledge that concept formation is a type of abstraction that is closely linked to experiences with objects and events. When a child matures, the abstractions involve mental or physical manipulations of signs, symbols, or classes of events and objects. For example, children will know that an object continues to exist when it is out of sight.

2.3.7.5 Learning through Interaction

Children learn by interacting with one another, playing together or solving problems together. Piaget (1967, as cited by Thornton, 2002) believed that children learn from collaborations where one child, perhaps an older sibling, has a different, and perhaps better, understanding of a problem or strategy for dealing with it. Both children's starting assumptions and approaches to the problem influence their decisions.

Children do not only learn from play, but also learn a great deal from joining in and helping with activities being conducted by adults or other children who are more experienced (Thornton, 2002). Vygotsky (1978) argues that, in fact, joining in and sharing some activity with a more experienced partner is one of the many ways in which children learn to understand the world and to acquire skills. It is not enough merely to watch a partner doing a task. Rather, it is sharing that activity that extends what the child is able to do.

2.3.7.6 Learning through Trial-and-Error

Children can learn by trial-and-error, from informal to highly systematic experimentation. Trial-and-error learning is the earliest stage in problem solving. There is a developmental sequence in children's ability to solve problems. Children try out solutions to problems in a random way and will try and fail many times, until they arrive at a solution (Beaver, Brewster, Jones, Keene, Neaum, and Tallack, 2001). Thorndike (1931) claims that the fundamental form of learning takes place through trial-and-error, that is, one tries something out and, if it functions well, one learns it. In other words, a selection takes place from what is learned, and on the basis of many experiments. Thorndike (1931) put forward the 'law of effect', which states that one learns what feels satisfying and the more this is repeated, the stronger the learning becomes. This is in line with the behaviourist theory which states that behaviourism is a view that operates on a principle of 'stimulus-response'. Jarvis (2006) suggests that from this perspective, learning is related to a relatively permanent change in behaviour as a result of experience. Trial-and-error learning can, however, be very frustrating for a child and careful adult intervention might be required.

2.3.7.7 Learning through Logical Reasoning

Children can also learn through logical and deductive reasoning. The foundations for logical reasoning can be laid at a young age and can be developed. Some of the experiences for developing logical reasoning are investigating and labelling the attributes of things, comparing things and noticing similarities and differences, using and describing certain things in different ways, and ordering things according to some dimension or relationship (Fisher, 2005). Children benefit greatly from this sort of experience, for example when they start making collections of items such as stamps or stickers. The skills of defining, ordering, classifying, sequencing and abstraction can be developed through open-ended questions. Logical reasoning involves many thinking processes, one of which is the deductive form of reasoning (Fisher, 2005). In everyday life adults and children are frequently required to go beyond the information given and make inferences that are not deductively valid. Reasoning by induction is then used to address gaps in the knowledge (Goswami, 2002).

2.3.7.8 Learning through Play

Play is a most important way in which children learn. It provides natural, fun ways to explore and to have trial-and-error experiences in a safe and enjoyable setting (Ramey and Ramey, 2004). Research shows that children learn best when they are having fun (see, for example Thornton, 2002; Vygotsky, 1978; Solter, 1992; Ramey and Ramey, 2004). When an emotion is engaged, events and ideas are committed to memory more strongly. Vygotsky (1978) regards play as an important part of children's growth and sees children's games and the things they use whilst playing as means by which culture is integrated with development. As adults we also more easily recall events in the past that are associated with strong emotions, including those that delighted us. This is why children learn more from interesting and creative play than from rote memory routines that are the staple of many accelerated learning programs. Play helps children acquire physical, social and intellectual skills whilst assisting them to understand and assimilate information.

2.3.7.9 Motivation

Appropriate motivation is essential. According to von Glasersfeld (1989), sustaining motivation to learn is strongly dependent on the learner's confidence in his or her potential for learning. These feelings of competence and belief in one's potential to solve new problems are derived from first-hand experience of mastering of problems in the past and are much more powerful than any external acknowledgment and motivation (Prawat and Floden, 1994). This relates to Vygotsky's zone of proximal development (Vygotsky, 1978) where learners are challenged within close proximity to, yet slightly above, their current level of development or competence. By experiencing the successful completion of challenging tasks, learners gain confidence and motivation to embark on more complex challenges.

2.3.7.10 Summary

Children gain from a rich environment of varied learning materials and facilities. The best materials are those that encourage children to be creative and imaginative, and stimulate them to build and think. Each child is different, develops at his own pace, and has a distinctive personal learning style. A stress-free environment that allows children to unreservedly express themselves, enhances the learning process. Learning can be prompted by encouraging exploration in children. They should engage in investigating new experiences and generating new information. Children can also be mentored by parents, teachers, and other adults in basic skills. Ramey and Ramey (2004) advise that the mentoring of young children should become increasingly direct and systematic. Over and above formal lessons, children can learn when adults teach them something of what they know and what is interesting in their everyday interactions. Such instruction and sharing are key components of mentoring. Adults should reward and celebrate children's development advances and the learning of new skills, be they small or great. Becoming a unique individual is a further achievement to be celebrated. Children are said to learn more and faster in positive circumstances. Acknowledging children's achievements assures them that their learning successes are noticed and this encourages them to attain even more.

2.3.8 Comparison between Adult and Child Learning

There is a difference between the ways in which adults and children learn (Knowles, 1973, 1984; as cited by Ference and Vockell, 1994). In the following subsections, l discuss the differences and similarities that have emerged from the previous discussions on how the two groups, children and adults learn.

2.3.8.1 Differences

This subsection uses the learning characteristics of Ference and Vockell (1994) as a basis. An integrated discussion of similarities and differences between adult and children learners, based on those characteristics and on the discussion in Sections 2.3.5 to 2.3.7, is given here.

a) Incidental learning

Young children of age ten onwards engage in incidental learning through exploration. Adults, on the other hand, experience incidental learning while doing their day-to-day work or when they are involved in planned learning.

b) Self-directed

Children depend upon adults for material support, psychological support, and life management. For example, a teacher is responsible for deciding what, when, and how learning will occur and how it will be assessed. Children are other-directed, while adults depend upon themselves for material support and life management. Although they must still meet many psychological needs through others, they are largely self-directed in that they are responsible for deciding what, when, and how learning will occur and how it will be assessed. However, Leberman, Mcdonald, and Doyle (2006) argue that these differences are relative and vary from one situation to another. They can change according to context. For instance, a young child may be a self-directed learner as they build a structure such as a fort with blocks or outdoor materials, but may revert to being other-directed for classroom mathematics. An adult may be self-directed in relation to a personal project such as digital storytelling, while they need to be other-directed in terms of learning how to swim.

c) Motivation

According to Webster, Zachariah, McFaury, and McMullin (2001), children and adult learners also differ in terms of the motivation for learning. Adults tend to learn specific skills that may, for example, be applied in the workplace. They do this as a means to a specific end, identified by the learner personally (Knowles, 1998). The adult's application of learning is more immediate and relevant to their particular life circumstance. A child's learning is motivated by their natural curiosity about the world. Instead of learning pertinent skills that will be useful in the immediate present, children often learn about skills that may be useful in the future. The application of a child's learning does not take on the same urgency as that of adults. Children learn because learning will be relevant in the future. They are often externally motivated by the prospect of good grades, as well as by praise from teachers and parents. This is called extrinsic motivation. Adults, on the other hand, are more concerned about the immediate relevance of learning and are more often internally motivated by the potential for feelings of worth, self-esteem, and achievement (Leberman, Mcdonald and Doyle, 2006). This is termed intrinsic motivation.

d) Value-driven

Children perceive one of their major roles in life to be that of learner, while adults perceive themselves to be doers, using previous learning to achieve success as workers, parents et cetera. (Ference and Vockell, 1994). Children, to a large extent, learn what they are told to learn. Adults learn best when they perceive the outcomes of the learning process as valuable, contributing to their own development and success, either in their work or in some other interest. Children view the established learning content as important because adults tell them it is important, yet these adults often have varying ideas about what is important to learn.

e) Experience-based

Adults and children also differ in terms of experience. Leberman, Mcdonald and Doyle (2006) argue that, for children, little attention or value is placed on the learner's experience. A child's formal learning is often through a combination of question and answer tests, rote memorisation and drills, e.g. learning multiplication tables. This technique, however, does not work well for adults who not only become bored by it, but view it as irrelevant and as a process which is inappropriate to the way they tend to want to learn new things. For adults, the learner's prior learning and experience is seen as the rich basis for learning. They are encouraged to make connections between prior experiences and the current learning task. Adult learners' experiences of life are broader and more diverse than those of a child. The adult learner applies his learning through relating it to certain experiences he has had.

f) Life-centred

An adult will have had more experience of life in general than a child and this provides an adult with a better foundation than a child when it comes to learning. However, it can also be a hindrance and a child’s lesser experiences can occasionally prove more beneficial because an adult tends to have more rigid learning patterns, based on previous approaches. An adult can be less willing to explore new ways of doing things. This can hinder progress. A child is usually keen to explore and remains more open-minded than adults who may be reluctant to go beyond their comfort zone. Children have less well-formed sets of expectations in terms of formal learning experiences. Their ability to filter past experience is less than that of adults. Adults have well-formed expectations, which, unfortunately, are sometimes negative because they are based upon unpleasant formal learning experiences in the past (Cave, LaMaster and White, 2006).

As a cohort within educational settings, children are much alike. They are approximately the same age, come from similar socio-economic backgrounds, et cetera, whereas adults are very different from each other (Cave, LaMaster, and White, 2006). Adult learning groups are likely to be composed of persons of many different ages, backgrounds and educational levels. The collective experience of an adult group is much richer than that of a child group.

g) Time-driven

Children perceive time differently from the way in which older people do. Perception of time changes as people age; time seems to pass more quickly as one gets older. In addition to perceiving time itself differently, adults are more concerned about the effective use of time. Children generally learn quickly and are open to new information and will readily adjust their views. By contrast, adults tend to learn more slowly. They are much more likely to reject or explain away new information that contradicts their beliefs (Cave, LaMaster, and White, 2006).

h) Readiness to learn

There is also a significant difference between the two groups’ readiness to learn. Children's readiness to learn is linked to both academic development and biological development. Adults' readiness to learn is more directly linked to needs such as fulfilling their roles as workers, spouses and parents and coping with life changes (divorce, death of a loved one, retirement). For children, instruction is designed to provide a standardised, step-by-step programme of education. Learners progress systematically through the prescribed steps. For adults, formal learning is often determined by the need to know or to learn for real-life problems or tasks (Leberman, Mcdonald, and Doyle, 2006).

h) Independent and directed learning

Children depend on adults, especially teachers or parents, for their learning processes. Adults are independent learners. Directed learning, in an educational environment, is characterised by the teacher in the role of expert and authority figure, transmitted knowledge, and passive learning. There is usually a standardised curriculum and mastery of content is expected. Directed learning is frequently used with children and is teacher-centred. Directed learning contrasts with self-directed learning, which empowers learners to negotiate their own learning agenda. Self-directed learning occurs more with adult learners (Herod, 2002). The adult learner takes the initiative and the responsibility for what occurs. The adult learners select, manage, and assess their own learning activities, which can be pursued at any time, in any place, through any means (Gibbons, 2002).

In comparing adult learning and child learning as discussed in the previous sections, fewer similarities emerge than differences.

2.3.8.2 Similarities

The following similarities emerged:

a) Incidental learning

Incidental and conscious learning are types of learning. For an adult, incidental learning is unplanned, and unanticipated learning outcomes are not identified as part of a formal curriculum. Marsick and Watkins (1986, p.187) define incidental learning done by adults "as a spontaneous action or transaction, the intention of which is task accomplishment". Learning not to repeat mistakes, learning through practice, and learning from one's network of friends, family and acquantainces all form part of incidental learning. For children, incidental learning occurs when a learner is doing something that is fun on his own or even with other children around. He can be learning a great deal without even realising it. Therefore, for both children and adults, incidental learning is learning that is done without planning.

b) Self-directed learning

Self-directed learning is a process in which learners are given a great deal of responsibility for, and input into, their own learning. Brookfield (1995) argues that self-directed learning is the process by which adults take control of their learning. While adults are expected to be more independent, children can learn the skills they will need for independence early in life by experiencing some components of self-directed learning. Likart and Hohmann (1995) describe the need for children to direct their own learning, that is, to be exposed to child-directed learning, with the teacher, as facilitator, guiding the process as it relates to the child's interests and goals. This type of curriculum is called active learning. It is defined as learning in which the child, by acting on objects and interacting with people, ideas and events, constructs new understanding. Most learners, adults and children alike are best motivated when they are self-directed and take responsibility for their own learning.

c) Action learning

Another similarity emerging from the discussions in the previous section is that both adults and children learn more by doing than by listening, that is, learning occurs through hands-on experience. Children and adults construct their knowledge of the world around them through their own experiences. Children, as pointed out by Becker and Becker (2008), learn to interpret and represent their world in symbolic language through activities such as drawing, painting, clay modelling, collage, dance, music, puppetry and dramatic play. They can express their thoughts to attentive adults who then engage them in meaningful dialogue. Adults frequently do on-the-job training, which takes place in a normal working situation, as they use the actual tools, equipment, documents or materials that more experienced adults use. So, although the tools or language may differ, the underlying process is very similar.

d) Fantasy and imaginary learning

Although this is more generally attributed to children, both children and adults engage in fantasy and imagination (Woolley, 1997). Adults engage in role play and day-dreaming. Children engage in fantasy play and imaginary learning. Children are often viewed as being unable to differentiate fantasy from reality. They believe in the reality of fantasy figures. A very young child may initially be somewhat unsure about attributing human-like properties to various entities. As they grow older, with experience, children acquire increasing knowledge about everything in their world, both about real entities and their properties, and about such socially supported myths as Santa Claus and the Easter Bunny.

Thus, there is the simultaneous development of beliefs considered correct (e.g. dinosaurs are real) and of beliefs considered incorrect but age-appropriate (e.g. Santa is real). This is neither unquestionably real nor pretend, but somewhere inbetween (Sharon and Woolley, 2004). It is suggested that children are not fundamentally different from adults in their ability to distinguish fantasy from reality (Woolley, 1997). Learning, to be more effective, should be based on the learner's experience (Brookfield, 1995). Both children and adults have opportunities in their learning to reflect on their life-experiences to explore concepts of family, culture and nature in their own way.

2.3.8.3 Conclusion

Learning in adults and children is qualitatively different, not just because the learning capacity of the brain gradually matures, but also because their life situations are essentially different (Illeris, 2006). In childhood, learning is typically uncensored and trusting. Children seek to acquire as much as possible and must trust adults to present them with what they need to know. Children develop their thinking abilities by interacting with other children, adults and the physical world. The background and culture of the learner is vital, for it shapes the knowledge and truth that the learner creates, discovers and acquires in the learning process (Wertsch, 1997)

In adulthood, learning is fundamentally selective. Adults concentrate on learning things that concern work, careers, family and interests. Learning is motivated by a need to become more self-directed and selective. In spite of differences in learning between adults and children, however, the learning orientation of both groups is "characterised by a gradual (detachment) from societal ties, individuation in learning interest, and increased personal responsibility for learning" (Illeris, 2006, p.213).

In conclusion, we need to acknowledge some fundamental differences between adult and child learners. First, adults differ from children in terms of the quality and quantity of life experience they possess. Secondly, children have not completed developing cognitively, emotionally or physically into mature human beings. Thirdly, children are generally not motivated to learn by immediate needs in their lives. However, despite these obvious differences, the educators of children and adults have a similar task. Both sets of learners benefit from some degree of facilitated self-directed learning and experiential techniques (Webster et al., 2001).

The next section will discuss learning strategies as these help learners in enhancing learning.

2.4 Learning Strategies

2.4.1 Definitions of Learning Strategies

There has been disagreement among researchers regarding what learning strategies are. Finkbeiner (1998) describes the problem as being caused by both research methodology and education that has arisen from a lack of coherence in the usage in the literature of terms such as ‘learning strategy’, ‘learning techniques’, ‘learner strategy’, ‘learning style’ and ‘communication strategy’. Finkbeiner (1998) states that some authors do differentiate between these terms, whereas the majority use them interchangeably. A third group subsumes one concept under another, thus creating a conceptual hierarchical framework.

A strategy refers to a plan concerning how one learns to do something. It can also be defined as a long term plan of action or a method a learner can use to learn something or to achieve a particular goal. Learners use various strategies to accomplish their learning needs.

Some definitions given by different researchers are given below:

- Learning strategies are the techniques and skills that an individual elects to use in order to accomplish a specific learning task. Such strategies vary by individual and by learning objective (Conti and Fellenz, 1991).
- Quam (1998) defines learning strategies as those tactics used by people to adapt to whatever situation they are confronted with in order to learn something effectively.

- Learning strategies are viewed as the cognitive tools used to systematically manage the thought-process associated with knowledge and skill acquisition (Anderson, 1992).
- Nisbert and Shucksmith (1986) define learning strategies as the processes that underlie performance on thinking tasks.
- A learning strategy is an individual's way of organizing and using a particular set of skills in order to learn content or accomplish other tasks more effectively and efficiently in school as well as in non-academic settings (Schumaker and Deshler, 1992).
- According to Oxford (1990), learning strategy refers to the use of a plan, step or conscious action toward achievement of an objective. Oxford expands on this definition by stating that learning strategies are plans of action that the learner formulates and puts into practice in order to make the learning process successful.

Finkbeiner (1998) observes that more recent literature in the field of learning strategies displays more commonality in the definition of the term. The common themes found in these definitions include purposefulness and self-directedness in the process of learning, and these attributes are increasingly being accepted as a model of learning that is a starting point for research and analysis.

Much of the research in the area of learning strategies has used the Self-Knowledge Inventory of Lifelong Learning Strategies (SKILLS). This valid and reliable instrument consists of real-life learning scenarios with responses drawn from the areas of metacognition, metamotivation, memory, critical thinking, and resource management (Conti and Fellenz, 1991). This research has consistently found that various groups of learners can be distinguished by the learning strategies which they use.

Learning strategies should be seen as the intellectual resources that enable learners to plan, organize, monitor, guide, and reflect on learning. Their use is based on cognitive theories of learning that view learning as the process by which information is interpreted, related to the learner's existing knowledge and skills, and organized for later retrieval. (Scheid, 1995; as cited by Anderson, 1992). The belief that learners interact and elaborate on their experiences has prompted both researchers and practitioners to pay closer attention to the ways learners consider, and make sense of, instructions.

Other researchers view learning strategies as determining the approach for achieving the learning objectives and are included in the pre-instructional activities, information presentation, learner activities, testing, and follow-through. These strategies are usually related to the needs and interests of learners to enhance learning and are based on many types of learning styles (Ekwensi, Moranski, and Townsend-Slet, 2006).

Considering the multiple definitions coined by researchers in the area of learning strategies, the one that best fits with my research is the approach that views strategies as skills that help an individual to learn new things and be able to accomplish them and even excel. A discussion follows on what previous researchers consider as adult's and children's strategies.

2.4.2 Adult Learning Strategies

Adult learning strategies can be plans and/or activities that help adult learners construct their own knowledge or learn new applications. There are a wide variety of learning strategies, and strategies appropriate for one learning situation may not be appropriate for another (Linstein and Mayer, 1986). In this section, I focus on strategies that are relevant to the study, namely those that may play a part when an adult learns to use a computer application. I will distinguish between active learning strategies and self-regulated strategies.

2.4.2.1 Active Learning Strategies

Active learning strategies, as described by Bonwell and Eison (1991), are those strategies that involve learners doing things and also reflecting on the things they are doing. Active learning is considered by researchers as a key element in the learning process of adults because the strategies promote learners' exploration of their own meaning, attitude and values and empowers learners to take primary responsibility for their learning. Active learning strategies are effective in engaging learners and assisting them in creating their own learning experiences.

2.4.2.2 Self-Regulated Strategies

Self-regulated learning strategies are strategies that promote self-regulated learning (Anderson, 1992). Chen (2002) points out that these strategies are personal capabilities that enable learners to be independent learners and to develop core resilience.

According to Zimmerman and Martinez-Pons (1989, p.392), self-regulated learning is a self-initiated action that involves goal-setting and regulating one’s efforts to reach the goal, self-monitoring (metacognition), time management, and physical and social environment regulation. Self-regulated learners are therefore individuals who are “metacognitively, motivationally, and behaviourally active participants in their own learning process”. Self-regulated learning is particularly appropriate for adult learners, as they have control over their own time schedules.

Chen (2002) gives the following examples of self-regulated learning strategies in the specific context of learning to use software applications:

a) Self-efficacy

Being confident in one's ability has been shown to positively influence learning outcomes and performance in the computer software domain. When an individual is confident, it tends to result in improvement.

b) Establishing specific work task goals

Adults can establish specific work goals or learn to complete specific work tasks during the learning process.

c) Focus on time spent learning

Adults can usually assess whether they spent their time fruitfully, therefore time management is very important.

d) Note-taking

Note-taking is a helpful strategy for adults, given the fact that adults have a great deal to think about in their lives and constantly write what they learn. Once they have internalise something, they can abandon the notes. When software becomes complex, then one has to do frequent note-taking.

e) Self-reward

The self-reward strategy can help an adult learn. If one needs to learn something to get something done or to make something happen, they will do it. One can learn in order to get advancement in the workplace or so that work is easier to do because of the new knowledge.

f) Frustration monitoring

There are various frustrations that adults might experience during computer software-related learning experiences. A strategy of frustration monitoring can help adult learners, regardless of how well they are doing when trying to learn new things.

Adult learning strategies focus on metacognition, because adult learners prefer to learn through self-assessment and self-correction and prior experiences. Metacognition concerns knowledge of one's own mental processes (Nisbert and Shucksmith, 1986). This awareness is an essential ingredient of many of the strategic activities in which adults are interested.

2.4.3 Child Learning Strategies

Learning strategies allow children to encode, recall, and process information (Siegler and Araya, 2005; as cited by Ellis, Asamen, and Berry, 2008). The strategies used by children vary with age and experience. Research suggests that children use learning strategies to solve learning problems, but that they contemplate and adjust their strategies based on previous experiences, reflection, or the environmental feedback they receive. Such feedback may be provided by a mentor or may result from the success or failure of attempting to solve the task itself. The learning endeavor is impacted by factors that are both internal and external to the learner (Ellis, Asamen, and Berry, 2008).

Some examples of children's learning strategies are:

a) Maintenance rehearsal

According to Baine (1986), maintenance rehearsal refers to the simple repetition of items to hold them in working memory, where the learner is conscious of them. When, for instance, we need to remember a phone number for long enough to dial it, or write it down, we repeat it to ourselves until we have completed our action. Maintenance rehearsal no doubt seems a self-evident strategy to any adult, simple as it is and long accustomed as we are to using it. However, it is, like any strategy, something we have to learn to do. It is rare for five-year-olds, but common for ten-year-olds.

b) Categorising

Categorising is another strategy that children can use to help them remember items. Suppose children are given a list:

ORANGES SOUTH AFRICA TRUCK JAPAN MOTORCAR PEACH BUS MANGO AMERICA

Baine (1986) asserts that these items will be much easier to remember if they note that the items belong to only three categories: fruits, countries, vehicles. Noting that there are three examples of each will also help. Category labels help considerably when it comes to retrieving the information. Knowing how many items are in each category tells us when we can stop searching that category and move on to another.

c) Mnemonics

Children can improve recall by using visual imagery. In a verbal mnemonic, words to be remembered are linked together in a sentence or sentences. It is an effective strategy for learning a list of words. Research confirms that memory, even in very young children, can be helped by teaching them to use this verbal mnemonic strategy (Baine, 1986).

It is more effective if the words (usually nouns) are linked by verbs rather than prepositions. Simply stringing together words like this: The *cat* and the *banana* and the *boat* were in the *sky*" is much less memorable than this: "The *cat* ate the *banana* and tossed the *boat* into the *sky*". Sentence mnemonics have been effectively used by 10-year-olds to remember the correct spelling of words (Baine, 1986).

The keyword method is one of the most successful mnemonic strategies to be used in education. Its effectiveness has been proved for learning new words, foreign language words, and social studies facts.

2.4.4 Learning Strategies and the Learnability of Software (an initial impression)

Learners use various strategies to accomplish their learning needs (Chen, 2002). After addressing examples of learning strategies, the learnability principles will be discussed by making reference to the child and adult learning strategies and how some of the learning strategies apply to the learnability principle, in particular.

2.4.4.1 Advance Organisation

Learning strategies that can be related to the learnability of software are strategies for planning how to learn, and strategies of learning. There is *advance organisation*, whereby one does a preview of what one is going to learn. For example, in learning a new software application, it will be helpful to read the 'Read Me' file first before doing any other activity. Advance preparation is another strategy one can use. It involves planning and preparing what one requires for learning well in advance, e.g. the environment, such as the acquisition of an appropriate computer and whether it has the required applications for the intended learning process.

2.4.4.2 Directing Attention

Directing attention involves paying attention to studying directly within a focus area or in line with the objective the learner wishes to achieve. Selective attention can be used in studying things that one can remember more easily. For example, if a learner plans to learn to use 'PowerPoint' then he should study ways of doing presentations.

2.4.4.3 Self-monitoring strategy

The s*elf-monitoring strategy* is correcting oneself on making a mistake when learning how to use new software. When a person starts to learn a new software application for the first time, he may want to watch while others, who are already familiar or already using those applications, demonstrate to him.

2.4.4.4 Self-evaluation

Self-evaluation (self-assessment or testing) strategy is applied when one uses a new software application after learning it and reflects on the experience. The self-reinforcement strategy means giving oneself a reward after successfully accomplished something, for example, giving oneself ten minutes of relaxation or ten minutes playing computer games.

2.5 Conclusion

The aim of this chapter was to describe the theoretical framework that forms the context for my research. In doing this, I introduced the chapter by discussing what researchers have discovered concerning the learnability principle and, more generally, how children and adults learn. A number of theoretical topics that potentially relate to the main focus of this research, such as learning theories and the learnability of software applications, were identified and reviewed in this chapter.

The issues that comprise the theoretical framework for this study are the learnability principle; the differences between how children and adults learn, including their respective learning strategies; adults and children acquiring specific new skills; how the learning strategies apply to using computer software, in general.

However, the researcher identified a gap in the literature. The literature does not show any formal connection between learning theory and the learnability principle. Previous research does not provide evidence of convergence between general adult/child learning styles and the specific learning styles involved in learning to use a new software application. This research will try to connect the two by conducting studies in the usability laboratory to compare operationalisation.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In order to create scientifically obtained knowledge using objective methods and procedures, the research process should involve the application of various methods and techniques (Welman and Kruger, 2001). The purpose of this chapter is to present the methods and techniques applied to reach the objectives of this research. It begins with a discussion of the mixed methodologies (triangulation) approach used in the study. Included in the chapter are details of the population selected for the study, sampling procedures, qualitative and quantitative instruments used, data collection methods used, and how data was analyzed.

A research design is a strategic framework that guides research activities. According to Durrheim (1999), a research design has four components:

- the purpose of the research,
- the research paradigm,
- the context, and
- the research techniques/methods employed.

In this chapter I discuss these components as applied to my research. The chapter will accordingly be organised as follows:
In Section 3.2, I discuss the purpose of the research. In Section 3.3 I discuss the research paradigm relevant to this study. Section 3.4 deals with the context of the research. In Section 3.5 the overview of the research process is given. The research techniques are explained in detail in section 3.6. In section 3.7 I discuss validity of measurement instrument and reliability of results and finally ethical cconsideration are discussed and I conclude the chapter in Section 3.9.

3.2 The Purpose of the Research

In describing the purpose of the research, the researcher has to specify who or what the objects of investigation were and, secondly, what approach was followed in studying them (Durrheim, 1999). In my description of the purpose, I will also give the thesis statement.

3.2.1 Objects of Investigation

The objects of investigation were adult and child users and specifically their behaviour while learning a new software application.

3.2.2 The Research Approach

According to Terre Blanche and Kelly (1999), research can be:

- exploratory, explanatory or descriptive,
- applied or basic, and
- quantitative or qualitative.

The type of research described in this dissertation is descriptive research. Descriptive research is viewed as representing a picture of the specific details of a situation, social setting or relationship (Neuman, 2003). I used this design as it is a scientific method that involves observing and describing the behavior of participants without influencing them in any way. The aim of the research as noted in the objects of investigation is to make a comparison between adults' and children's behaviour while learning a new software application. The use of this design will help me capture the different behaviours.

My research is basic as it seeks to increase understanding of fundamental learning principles. Basic research generates new ideas, principles and theories, which may not be immediately utilized, though they are the foundations of modern progress and development in different fields. It stimulates new ways of thinking that has the potential to dramatically improve how practitioners deal with a problem. In my research I will be comparing the meaning of the learnability principle for children and adults. My aim is that readers especially designers of software, achieve a deeper understanding of the learnability principle in the context of how children and adults learn new software applications.

In my research I selected a qualitative research design and methodology as the main method for analysing my data. I did this because I wanted to capture data about the participants' learning behaviours. Qualitative research aims to help researchers understand new ideas and improve their way of thinking. Durrheim (1999) states that qualitative methods are naturalistic, holistic and inductive. They investigate the relationships that exist in nature, with the aim of deducing important meanings. Rubin and Babbie (2001) add that the advantage of qualitative research is that it provides a richer and deeper understanding of a problem or question being investigated, which often leads to better understanding of the human experience.

Crotty (1998) rightly mentions that research methods can be either qualitative, quantitative or both. In this study, some quantitative research was done for triangulation purposes. Triangulation is viewed as an important methodological issue in naturalistic and qualitative approaches to evaluation. It helps to control bias and to establish valid propositions. Traditional scientific techniques are often lacking in this regard (Golafshani, 2003).

3.2.3 Thesis Statement

The thesis statement that is examined in this dissertation is as follows:

In the context of Human Computer Interaction (HCI), the learnability principle has a different meaning for children and adult users.

3.3 Paradigm

Various research paradigms exist that help researchers to make data collection, analysis and interpretation decisions. Research paradigms provide a conceptual framework for the justification of choice of research methodology. According to Burrell and Morgan (1979, p.24), "to be located in a particular paradigm is to view the world in a particular way". The different research paradigms are based on varying philosophical foundations and concepts of reality that are implemented by associated methodological approaches and strategies (De Villiers, 2007). Galliers (1991) identifies positivism and interpretivism as major research paradigms.

The positivist paradigm views scientific knowledge in its purest form, basing it on pure observation that is free of environmental influences (Howe, 1988). The positivist paradigm supports the selection of quantitative methods as the methods of data analysis.

De Villiers (2007) points out that the positivist paradigm holds that knowledge is absolute and objective and that a single objective reality exists.

The interpretivist paradigm is characterised by a belief in a socially constructed, subjectively-based reality, one that is prone to the influences of the environment. Interpretivism rejects the positivist view of pure observations, but rather recognizes the inevitability and desirability of environmental impacts on observation.The underlying assumption of interpretivism is that the whole needs to be examined in order to understand a phenomenon. As a consequence of this, qualitative methods of analysis are well-suited to interpetivist investigations. Howe (1988) proposes that investigations must employ broad-based understandings of phenomena (as opposed to the narrower aims of explanation, prediction and control that characterise the positivistic viewpoint).

In my study, I drew upon both the positivist and interpretivist research paradigms in the collection, analysis and intepretation of data. When I conducted experiments in the usability laboratory and used quantitative methods to analyse the data, this represented an application of the positivist research approach. Using qualitative methods, I also analyzed the observed differences in the understanding of the meaning of the learnability principle by adults on the one hand and children on the other. This analysis resulted in the interpretation of observed differences as a series of insights. Such qualitative data analysis and interpretation represented an application of the interpretivist research paradigm.

3.4 The Context

Research always takes place in a specific context. The way the researcher views the context will depend on the research paradigm. Positivists, whose research is mostly experimental and quantitative, usually try to control and manipulate the context of the research. Interpretivists, on the other hand, regard the context, both their own and that of the object of their study, as having a material impact on the investigation. For this reason, interpretivists take environmental impacts on the investigation into account in their research designs. My research was conducted in the general context of the HCI discipline.

Another aspect of the context is the current situation where children are often more comfortable with technology than adults, as children are exposed to computers from a very early stage. This played an important role in the study as prior experience and social and cultural characteristics necessarily influence how users approach a new software application.

The empirical work took place in the usability laboratory at the University of South Africa in Pretoria. The children used as participants were drawn from two different schools in Pretoria. These specific schools were chosen because they have fully equipped computer laboratories, where all pupils attend computer lessons during school hours. After school hours there are computer clubs and extra lessons, thus all the learners have had equal exposure to the use of computers. The schools were also easily accessible to me. Adults were drawn from employees in different departments of the University of South Africa (UNISA). The reason for choosing UNISA was because it was easily accessible and the computer laboratory is situated there, so the participants could easily visit the laboratory for the experiments.

3.5 Overview of the Research Process

The study consisted of a pilot study and a main study.

3.5.1 Pilot Study

A pilot study was conducted using two children and an adult. One was the expert and the other one a novice. The purpose of the pilot study was to gather data to reduce risk and uncertainty about the actual study. Olivier (2004) says that a pilot study helps to eliminate annoying problems which can be encountered when one is doing the main study. This pilot study, therefore, was to test the feasibility of the research design and research methods, and to make changes in the main study in the light of lessons learned from the pilot study. Based on the pilot study, a number of activities were redesigned to be able to be used by the participants. In the pilot study I used an expert child to teach both the child novice and the adult novice. I realised that the behaviour of the 'teacher' also provides useful information, therefore I decided to include the following:

- Child experts teaching children and adult novices one of the software applications,
- Adult experts teaching children and adult novices one of the software applications,

- Child novices teaching themselves one of the software applications,
- Adult novices teaching themselves one of the software applications,
- Eye-tracking was used when collecting data on participants who taught themselves.

3.5.2 Main Study

The main study involved 28 people participating in the usability laboratory experiments. Each experiment involved 3 consecutive stages. In Stage 1 the participants were asked to complete a few demographic questions aimed at obtaining information about their computer experience with the software applications used in the study. The questionnaire appears in Appendix B. In Stage 2, various activities were conducted for data collection. These will be discussed in detail below. In Stage 3, unstructured interviews were conducted immediately after each session to determine some of the parts where clarity was required (see Appendix B).

In the sections below I will discuss the details of the experimental setup, the organisation of the different experiments, and the research methodology.

Setup

The experiment sessions were conducted in the usability laboratory at the University of South Africa. This enabled the participants to learn the software applications they were unfamiliar with, without researchers being in the same room. The usability laboratory consists of an observer room and a participant room, separated by a one-way mirror. The participant room (Figure 3.2) is equipped with a 17" Thin Film Transistor (TFT) monitor with resolution of 1280 x 1024 and a Tobii 1750 eye-tracker, allowing the eye movement of participants' eyes on the screen to be recorded. A 9-point eye tracking calibration was used at all times. Eye tracking video recordings included a cursor which indicates the participant's eye movements. The camera was angled to capture facial expressions, keyboard and mouse use, as well as general activity around the computer. An external microphone was switched on to capture audio among the participants and also for any instructions to the participants from the researcher. A four-port audiovisual switch captured input from the cameras as well as the computer, allowing for synchronized recording of both audio and video onto one Video Home System (VHS) cassette. The VHS recorder was attached to a portable digital video recorder for conversion to digital format for easy playback on a computer.

The observer room (Figure 3.1) consists of two Dell monitors that capture all video streams to storage, video and sound equipment and an Altinex machine for setting camera views. The video and sound equipment allows live video recordings (including the screen, the participant's face and mouse/keyboard actions). This system records behaviour using video and sound recording.

Figure 3.1 Unisa HCI Laboratory Observation Room

Figure 3.2 Unisa HCI Laboratory Participant Room (*Used with permission from the subjects*)

The software applications given below were loaded onto the computer:

- Timez Attack,
- StoryBook Weaver,
- Microsoft Outlook 2003,
- Microsoft PowerPoint 2003.

In addition to myself, a laboratory manager was present in the laboratory during experiments to set up the equipment used and to explain procedures related to eye-tracking to participants who were working individually.

3.5.3 The Organization of Experiments

The data gathering involved observing, video recording and recording eye-tracking data of the participants. Some sessions involved single users and some required different combinations of pairs of participants. The alternatives are described below:

a) Child experts were observed teaching either a child novice or adult novice: They first demonstrated how the software application was used. The novice then repeated what had been demonstrated by the expert.

b) Adult experts were observed teaching either a child novice or adult novice: They demonstrated how the software application was used. The novice would then repeat once what had been demonstrated.

c) Novice children teaching themselves one of the educational games: Eye-tracking was used as an additional data collection method in this case.

d) Novice adults teaching themselves one of the educational games. Eye-tracking was used as an additional data collection method in this case.

The video recording was used to capture all the behaviours of the participants while carrying out the experiments. Over a period of three months, the participants were observed and videotaped (altogether 13 sessions of approximately 45 to 60 minutes each). All the experiments were carried out in English, which is one of the 11 official languages of South Africa. This was the language common to all the participants. A total of 28 participants was used.

3.6 The Research Techniques

A description of the research methodology has the following three elements: sampling, data collection and data analysis (Durrheim, 1999).

3.6.1 Sampling

One goal of scientific research is to describe the nature of a population, a group or class of subjects, variables, concepts and phenomena. In most situations however, an entire population cannot be examined due to time and resource constraints. The usual procedure in these instances is to take a sample from the population that is representative of the entire population.

Sampling is the process of selecting units (e.g. people, organisations) from a population of interest so that by studying the sample we may fairly generalise our results back to the population from which they were chosen (Puttergill, 2000; Trochim, 2006). Mouton (2001) defines a sample as elements selected with the intention of finding out something about the total population from which they are taken. The sample size is also important to note. According to Durrheim (1999), the size of a sample in any study depends on the type of study conducted, although practical constraints may also have an influence. By including specified inclusion criteria, the sample becomes homogeneous, which means that there is not much variation within the sample, allowing for a smaller sample size (Durrheim, 1999; Patton, 2001).

The type of sampling used in this study was convenience sampling. Convenience sampling (sometimes known as grab or opportunity sampling) is described by Leedy and Ormrod (2010) as a type of non-probability sampling (subjects chosen in a non-random manner) which involves the sample being drawn from that part of the population which is close to hand. It is a sample population that is selected because it is readily available and convenient.

This type of sampling was chosen due to accessibility and proximity of the participants to the research facilities. The participants were chosen from two schools to which I had access, and from the University of South Africa where I work. I chose children who were from age 9 years to 12 years because the pilot study indicated that this age group can cope well with the requirements of the experiments. Adults were drawn from workers of University of South Africa's different departments. The reasons for choosing UNISA was because it was easily accessible and the computer laboratory to be used was at this campus so the participants could easily visit the laboratory for the experiments.

Participants

When doing research it is important to think about how one is going to choose participants. A researcher should choose participants who would be able to provide the information required. According to Greig and Taylor, (1999) many forms of doing research require the participant's mastery of a number of basic cognitive skills, such as understanding of verbal material, a certain attention span, memory capacity, understanding of certain symbols, understanding of conversation rules. According to Dumas and Redish (1993), selecting the participants for research has the following steps:

- developing user profiles,
- selecting subgroups for a test,
- defining and quantifying characteristics for each subgroup,
- deciding how many participants to include in a test.

In this research, participants were children and adults since the research required comparing these two groups. Children from the ages of 9 to 13 years were invited to take part and a sample was chosen from the volunteers. They are an appropriate age group to include in usability research, because of their experience with computers. They are able to follow a task with specific directions and have a higher attention span. Children think differently from adults and there are qualitative differences in the way children of different ages understand the world around them (Hanna, Risden and Alexander, 1997). On the other hand children of this age group are suitable because they can concentrate long enough to perform an evaluation in a usability laboratory or at school (Hanna, Risden and Alexander, 1997). The adult participants' ages ranged from 35 to 50 years.

The number of participants in the experiments was 28, of which 12 were children and 16 adults. Some of the participants were experts and others novices. Five of the participants acted both as experts and novices as there were software applications with which they were familiar with and other applications which they had not used before. Some children came from Glenstantia Primary School and others from Anton van Wouw Primary School, both in Pretoria, and the adults were employees from the University of South Africa. Table 3.1 below shows the profile of the participants.

Table 3.1 Participants' Profile

NAME	AGE (in years)				EDUCATION HISTORY			EMPLOYMENT HISTORY			COMPUTER EXPERIENCE				SOFTWARE APPLICATION EXPERIENCE			
	9-11	12-13	35-40	Over 40	Primary School	High School	Higher Education	Employed	Unemployed	Not Applicable	Low	Moderately Low	Moderately High	High	Times Attack	StoryBook Weaver	Microsoft Outlook	Microsoft PowerPoint
CE_{1}		√			√					√				√	Yes	Yes	No	Yes
CEN_{2}		√			√					√			√		No	Yes	No	Yes
CE_{5}	√				√					√			√		Yes	Yes	No	No
CN_{6}	√				√					√		√			No	No	No	Yes
CN_{10}		√			√					√			√		No	No	No	Yes
CEN_{8}		√			√					√			√		No	No	Yes	Yes
CEN_{7}		√			√					√			√		No	Yes	No	Yes
CN_{3}		√			√					√			√		No	No	Yes	Yes
CN_{4}		√			√					√		√			No	No	No	Yes
CN_{9}		√			√					√		√			No	No	No	Yes
CN_{11}		√			√					√		√			No	No	No	Yes
CN_{12}		√			√					√	√				No	No	No	No
AEN_{5}			√				√	√						√	No	No	Yes	Yes
AE_{1}				√			√	√						√	Yes	Yes	Yes	Yes
AN_{2}				√			√	√						√	No	Yes	Yes	Yes
AN_{4}			√				√	√				√			No	No	Yes	Yes
AEN_{3}				√			√	√						√	No	No	Yes	Yes
AN_{10}				√			√	√						√	No	No	Yes	Yes
AN_{11}				√			√	√					√		No	No	Yes	Yes
AN_{12}				√			√	√					√		No	No	Yes	Yes
AN_{8}				√			√	√				√			No	No	Yes	No
AN_{7}			√				√	√			√				No	No	No	No
AN_{6}			√				√	√			√				No	No	No	No
AN_{9}				√			√	√					√		No	No	Yes	Yes
AN_{13}			√				√	√					√		No	No	Yes	Yes
AN_{14}				√			√	√					√		No	No	Yes	Yes
AN_{15}				√			√	√					√		No	No	Yes	Yes
AN_{16}				√			√	√					√		No	No	Yes	No

KEY:

CE_1: Child expert number 1

CN_3: Child novice number 3

CEN_2: Child expert and novice number 2 *(This is when a participant was familiar with one of the applications and was not familiar with another)*

AE_1: Adult expert number 1

AN_2: Adult novice number 2

AEN_3: Adult expert and novice number 3. (*This is when a participant was familiar with one of the applications and was not familiar with another)*

A series of experiments was conducted in a formal usability laboratory. Each experiment involved a user learning a new application. With the help of a laboratory usability expert, I observed the following eight combinations of users:

1. A child user learning a new child product with the help of a child expert.
2. An adult user learning a new child product with the help of a child expert.
3. An adult user learning a new adult product with the help of an adult expert.
4. A child user learning a new adult product with the help of an adult expert.
5. An adult user learning a new adult product on his/her own.
6. An adult user learning a new child product on his/her own.
7. A child user learning a new adult product on his/her own.
8. A child user learning a new child product on his/her own.

The Figure 3.3 below shows an example of how participants participated in one of the applications. Child 1, who is an expert, would teach Timez Attack to Child 2 and Adult 1 who are both novices in this software application. Adult 2, who is an expert, would teach Timez Attack to Child 3 and Adult 3 who are both novices in this software application.

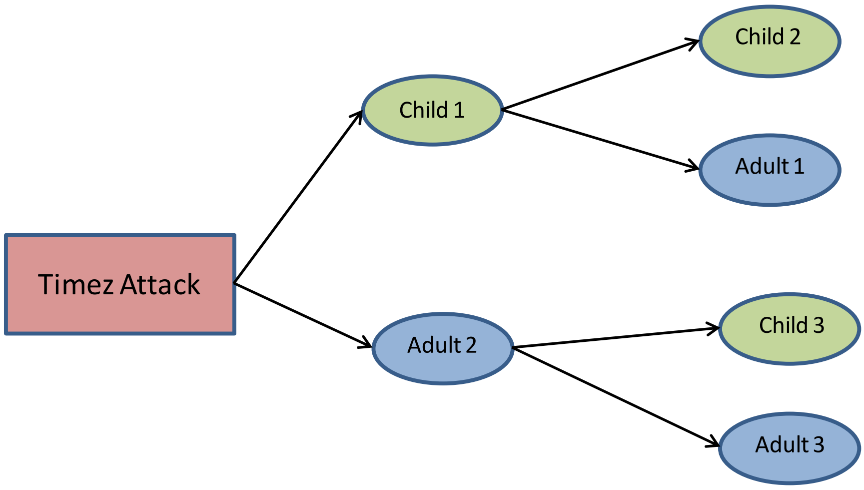


Figure 3.3 An example of the experiment procedure

Data was collected through observation, eye-tracking, video recordings and interviews with the participants.

Software Applications

The software used included child and adult products. The child products were:

- Timez Attack, and
- StoryBook Weaver.

The adult products were:

- Microsoft Outlook Application, and
- Microsoft PowerPoint.

The researcher chose the products, since they are software applications that are frequently used by both groups.

Timez Attack

Figure 3.4 Timez Attack game

Figure 3.4 shows a screen shot from Timez Attack. It is a tightly focused educational software program, cleverly disguised as a captivating video game. Timez Attack teaches children aged seven and older the multiplication tables. Users navigate an avatar (a little green alien) through dungeons in search of golden keys to open doors. The keys take the form of multiplication sums. When a key is found, the program takes the user through a sequence of events that helps to systematically build up the answer to the sum. For example, when the sum 11x3 appears on a door, three snail-like creatures each carrying the value 11 appear. The user (through the avatar) must catch them and, in the process, builds the answer to the sum. The collected 11s must then be thrown back at the door before the user is allowed to type the answer. If the answer is correct the door opens and an ogre appears who asks the child to do the same sum (and others previously encountered). When the user answers all of these correctly, he or she continues in the game.

Timez Attack uses the third person shooter-style genre of game play in which an avatar is manouvred through a set of levels while combating villains. Actions are controlled by the user through a view of following the character from behind. It merges recreational style computer game play with an educational goal. The main difference between Timez Attack and the recreational implementation of this genre lies in the attack mechanism. Instead of guns, knives or objects, answers to multiplication sums are used to defeat villains or open doors.

StoryBook Weaver Deluxe 2004

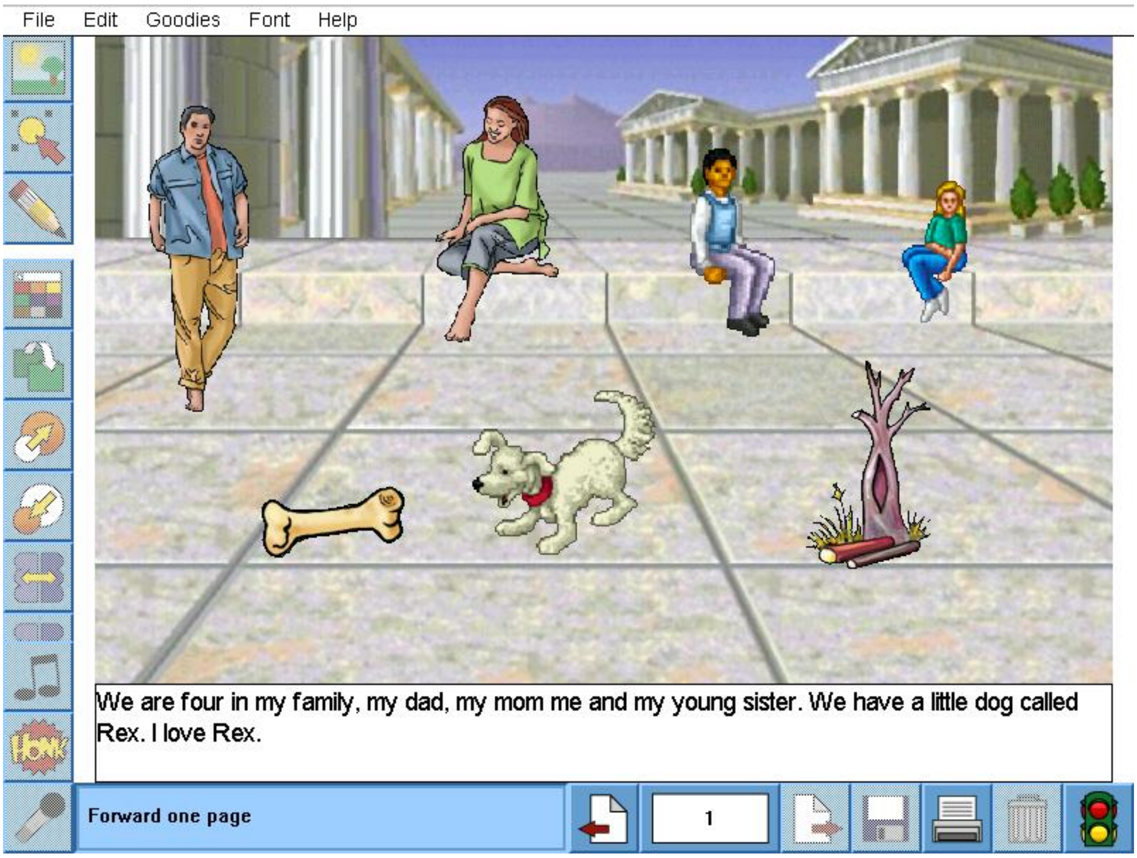


Figure 3.5 StoryBook Weaver game

StoryBook Weaver Deluxe 2004 is a software application for creating stories as shown in Figure 3.5. Users can choose from a large selection of backgrounds to create scenes on the pages of their electronic storybook and select from thousands of story characters and objects to create illustrations. StoryBook Weaver Deluxe is a game of the Classic genre for the PC Mac. The game commences with the title page where the user names the story, types in the author, and can add a decorative border. On the story pages the possibilities are endless. They begin with a background and users can choose between themes such as outer space, a king's castle, oceans and more. Objects are added by clicking on the symbol, (+), plus and apply button,(√), then picking from a variety of characters available to fit with the almost never-ending choices of scenery (Chimbo and Gelderblom, 2008). The size and orientation of objects chosen can be changed and even edited. Music and sound effects or recordings of the user's own voice can be added to narrate the story, which is written in the text area.Many fonts are available as well as a spell checker and thesaurus. Furthermore, the size and colour of the text can be customised.

The illustrations can be used as story starters to stimulate children's creative writing. The program is packed with over 1,800 images, 140 interchangeable scenery combinations, 37 colours, 69 page borders, 99 sound effects and 60 songs. Each page contains a text pane where the user can type the story text. Users can formulate story ideas that range from fantasy adventures to personal events to historical fiction (Gelderblom, 2008). They can create voice-overs to attach to pages or specific characters by recording their own voices, or they can use existing sound files for this purpose (Chimbo and Gelderblom, 2008). There is an extensive array of multicultural images from around the world.

A typical session proceeds as follows: a user starts a new story, types in a title and his name, then selects a border for the title page. Next, the user goes to the first story page where they pick a background scene and add story characters and objects. The user then types in the story text in the story window, and can also add background music and sounds to the page or story objects. If a microphone is attached to the computer, the user can use the Record button to record a voice-over for the story page. Users can create as many pages of their story book as they like. Using the Save button, they then save the story to disk. They also have the option (from the File menu) to publish the story as a Web document.

MS Outlook

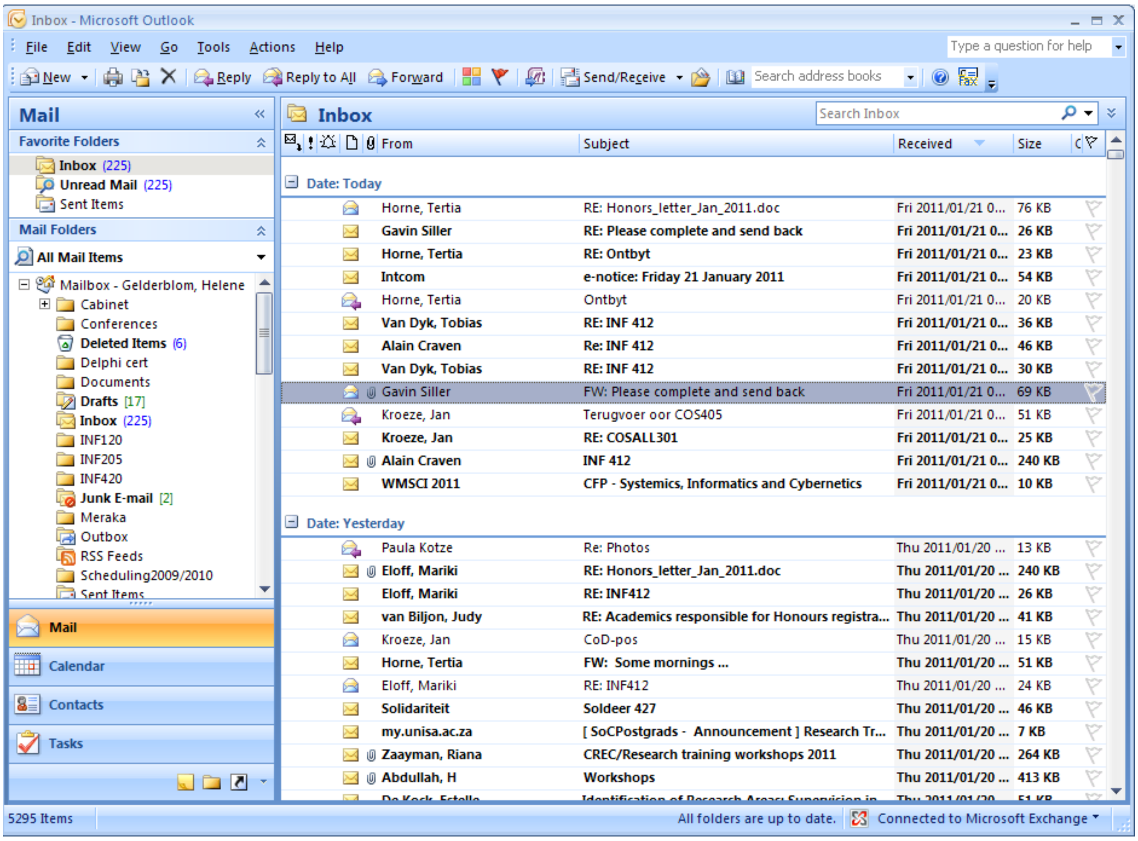


Figure 3.6 Microsoft Outlook Application

Figure 3.6 is an example of a well-known Microsoft Outlook application, which is an e-mail application in the Microsoft Office Suite. It manages e-mail, calendars, contacts, tasks, to-do lists, and documents or files on the hard drive. It is designed to operate as an independent personal information manager, as an Internet mail client, or in conjunction with the Microsoft Exchange Server for group scheduling, e-mail, and task management.

MS PowerPoint

Figure 3.7 Microsoft PowerPoint Application

Microsoft PowerPoint is a software product used to create computer-based presentations. There are various circumstances in which a presentation is made: presenting a conference paper, teaching a class, introducing a product to sell, explaining an organizational structure, amongst others. Figure 3.7 is an example of a PowerPoint application.

PowerPoint presentations consist of a number of individual pages or ‘slides’. The ‘slide’ analogy is a reference to the slide projector (a device that can be seen as obsolete) within the context of widespread use of PowerPoint and other presentation software. Slides may contain text, graphics, movies, and other objects which may be arranged freely on the slide. PowerPoint, however, facilitates the use of a consistent style in a presentation using a template or ‘Slide Master’ (Savoy, Proctor, and Salvendy, 2009). The presentation can be printed, displayed live on a computer, or navigated through at the command of the presenter. For larger audiences the computer display is often projected using a video projector. Slides can also form the basis of webcasts.

PowerPoint provides three types of movements:

- Entrance, emphasis, and exit of elements on a slide itself are controlled by what PowerPoint calls Custom Animations.
- Transitions, on the other hand are movements between slides. These can be animated in a variety of ways.
- Custom animation can be used to create small story boards by animating pictures to enter, exit or move.

3.6.2 Data Collection Methods

Various methods were used for collecting data and to provide triangulation to the study. The subheadings in this section are as follows:

- Observation and video recordings,
- Eye Tracking,
- Usability Testing,
- Interviews,
- Peer Tutoring,
- Think aloud.

Observation and Video Recordings

In observation, I carefully observed how people act and behave in situations relating to the research. Observation is a method that enables the researcher to study the interaction between participants in a variety of ways, for example ways to check for nonverbal expression of feelings, determine who interacts with whom, grasp how participants communicate with each other, and check for how much time is spent on various activities (Schmuck, 1997). Through observation, one can focus on the following observable behaviour:

- Confident readiness to experiment,
- Readiness to listen to suggestions from peers,
- Body language which can convey enthusiasm or boredom with an activity.

Hanna, Risden and Alexander, (1997) suggest that the researcher should evaluate the behavioural signs by observation. Behavioural signs such as frowns, sighs, yawns or turning away from the computer are more reliable than participants' responses to satisfaction questions. They also recommend that, after the observations or after the entire experiment is complete, the subjects should be rewarded by acknowledging how helpful they were. This is aimed at reducing the stress caused by the test. The participants could also be remunerated in the form of gifts or certificates.

Observations are essential in qualitative studies, because they allow the researcher to witness certain patterns of behaviour. The observation method which was used during learnability testing was unobtrusive observation, where concentration was on observing what the participants were doing and refraining as much as possible from influencing them by interrupting them with questions.

Since I used descriptive research, my primary data was obtained through observations. Observations for this study took place in the usability laboratory. For my observations to be useful and credible, observations were recorded. As a qualitative research data gathering tool, video recordings should be authenticated. The advantage of video recording is permanence (Grimshaw, 1982). It allows viewers to experience an event repeatedly by playing it back. With each repeated viewing, the researcher can change her focus somewhat and see things she had not seen at the time of taping or on previous viewings (Erickson, 1982, 1992; Fetterman, 1998). Replaying the event also allows more time to contemplate, deliberate, and ponder the data before drawing conclusions. I viewed the video recordings and transcribed them for analysis purposes. The schedule of the recordings made for this research is provided in Appendix A.

Eye Tracking

Eye tracking was another method used to collect data. This method was used when single participants were teaching themselves how to use one of the software applications. Eye tracking can be defined as a technique to determine eye movement and eye-fixation patterns. It is the process of measuring the point of gaze, at which the participant is looking or the motion of an eye relative to the head of a user. An eye tracker is a device used for measuring eye positions and eye movement.

In HCI, eye tracking has been used to study the usability of web pages (Jacob and Karn, 2003), menu searching, information searching from web pages and search result evaluation (Aula, Majaranta and Raiha, 2005). Eye tracking requires special equipment that can unobtrusively measure eye movement without interfering with participants' mental processing. It also does not require participants to verbalize their thoughts (Bednarik and Tukiainen, 2006; Bojko and Stephenson, 2005). Pretorius, Calitz and Van Greunen (2005) describe how gaze plots and heat maps, typical eye tracking visualisations, can be triangulated with user testing and evaluator observations. A gaze plot shows the participant's scan path, with fixations, while completing a task. A heat map shows the fixations of a participant where the 'hot' colours indicate areas most fixated by a participant. I used eye tracking to compare data recorded while children and adults taught themselves to play a computer game that they had not played before. Comparison of the on-screen focus points and eye-gazing patterns of the two user groups were used to test whether or not adults and children had different tactics when confronted with an unfamiliar game.

Usability testing can be augmented with eye tracking since a record of a person's eye movements while doing a task provides valuable information about the nature, sequence and timing of the cognitive operations that took place (Rudmann, McConkie and Zheng, 2003).

Usability Testing

The primary goal of usability testing is to improve the usability of a product (Dumas and Redish, 1993). For each test, there are also more specific goals, such as comparison with competitors products, or testing learnability or efficiency of systems. Usability testing technology can also be used to find out more about the actual learning processes and behaviours of users interacting with the systems (De Villiers, 2009). In the present study, I investigated learnability of software applications by studying tutoring interactions between children and adults.

Learnability principle is a component of usability testing, i.e. usability testing is a controlled experiment that tests how well people use a particular product. According to Holleran (1991, as cited by Chimbo, 2006), the aim of usability testing is to observe people using a product in a real-life situation in order to learn something new or discover errors and areas of improvement. Usability testing involves gathering information about the use of products or their prototypes from users who are not involved in the design of the products.

Usability testing always involves real users as participants in the tests. The participants do real tasks while the researchers observe and record their actions and comments. The participants perform a series of tasks while the observers watch them and take notes. Usually the participants are asked to think aloud while doing the tasks to get information about why they choose the steps they take (Dumas and Redish, 1993).

According to Holleran (1991), good usability testing is similar to good empirical research, for it is valid and reliable. *Validity* means that the test in fact gives an accurate measure of an attribute that is of interest and is relevant to the usability of the product. *Reliability* means that the results of a test can be repeated over time and with other testers. The validity of the test results can be enhanced by gathering data through several evaluation methods and by collecting quantitative data with which statistical analysis can be performed (Holleran, 1991).

In this research the usability testing methodology was modified to capture learning behaviour of users using software applications, rather than to test the usability of the software. I engaged in learnability testing that checks whether a software application is learnable.

Interviews

An interview is another technique which can be used for data collection. Interviews are a useful data collection method which enables respondents to give detailed responses about complex issues (Bowling, 2002). The main advantage of this approach is that it is flexible. It provides in-depth attitude probing into a particular issue and provides spontaneous information. The interview approach requires effective communication skills and the ability to explain questions well and to interpret answers well. For example, contradictions in the questions may be pointed out and explained right away. The main disadvantage is that it is time-consuming and hard to analyze and compare the data.

The variation in the factors mentioned above, necessitates adaptations in traditional testing procedures to cater for people who fall within different categories on the cognitive or developmental scale. Saywitz, Geiselman and Bornstein (1992), for example, suggest that interviewers adjust their language to a comparative level with that of the child under investigation at a particular stage of development, and make a developmentally sensitive interpretation of the child's statements. If it is an adult being interviewed, the same procedure takes place.

In this study I dealt with two different age groups, children and adults, but used the same guiding questions for both. The questions used as a basis during the interviews were adapted according to participants' feedback and new information that emerged during the experiments. The informal, semi-structured interview schedules were used to guide the face-to-face interview process (see Appendix B). This method was preferred to structured interviews, as participants were able to speak about their experiences and perceptions without being restricted. Durrheim (1999) recommends this type of interviewing and argues that both the participants and researcher have less chance of losing sight of the research problem being investigated.

The informal, semi-structured interviews were carried out at the end of each session. I held short interviews with both the novice and expert participants to discuss issues regarding how they felt during the experiment when they were being recorded, whether the software was easy or difficult to learn, which parts of the software applications they enjoyed and those they did not, and whether they were able to master all the required activities (see Appendix B for more questions). Feedback about their experiences was required. This was done in order to clarify the user's thought-processes, and to discuss where they had difficulty interacting with the instructional resource. I wrote down all answers and comments given by the participants.

Peer Tutoring

Höysniemi, Hämäläinen and Turkki (2003) define peer tutoring as the process whereby children teach other children in a familiar social setting to use software that is under evaluation. Peer tutoring involves individuals who have dissimilar levels of proficiency helping each other to learn. Sometimes older children help younger children, and sometimes more able children help less able children of the same age. Goodlad and

Hirst (1989) see opportunities to learn by teaching. Children are often very receptive to peer tutoring.

In this research peer tutoring was used when expert children, who knew the software applications being used, taught the novice children who had not used the application before.

Think aloud

Think aloud is a technique which was used in this study, when participants were asked to do a task and to speak about what they are doing whilst doing it. It is a useful technique as rightly pointed out by Rugg (2006) who argues that the technique gives insights into whether participants are tackling a task using pattern matching or sequential reasoning. It is also useful for identifying which things participants bother with, and which they do not notice.

Thinking aloud is one of the most direct methods to gain information about participants' internal states (Ericsson and Simon, 1998), therefore it is generally used in usability testing. It produces qualitative information about how participants perceive, interpret and understand the product and its documentation, and about the problems and difficulties they have in learning to use it (Kato, 1986).

While I used eye tracking to collect data from individual participants, they were also asked to think aloud. According to Penzo (2005) eye tracking introduces quantitative measurement to the field of usability evaluation, which typically provides qualitative data. Whether researchers are video recording or logging data during a usability test session, the think-aloud protocol supports the collection of qualitative data such as a user's mood through tone of voice and facial expressions, while the eye-tracker records quantitative data such as pupil diameter, fixation coordinates, fixation length, saccade angles, and more. The combined data of these two methods provides a broad overview of the problems a user encounters in an experiment while performing a task.

3.6.3 Data Analysis

The goal of data analysis is to structure the findings as interpretations and descriptions of user experience. The data analysis gives interpretation of what happened in a test

session, and what problems and successes occurred. Thorne (2000) argues that data analysis is the most complex and mysterious of all the phases of a qualitative project, and the one that receives the least thoughtful discussion in the literature. In order to generate findings that transform raw data into new knowledge, the researcher needs to engage in active and demanding analytic processes throughout all phases of the research. Understanding these processes is therefore an important aspect not only of doing qualitative research, but also of reading, understanding, and interpreting it.
A five step process given by Terre Blanche and Kelly (1999) was followed:

1. Familiarisation and immersion

Terre Blanche and Kelly, (1999, as cited by Gelderblom, 2008), establish familiarisation and immersion as representing a crucial stage in data analysis. This involves the researcher immersing himself/herself into the material gathered, by reading it repeatedly, taking notes and drawing diagrams, with the objective of obtaining thorough knowledge of the collected data.

To give relevant information, it was important to become thoroughly familiar with the aspect of learnability of software interfaces. The outcome of this step would be the production of written descriptions of those specific behaviours observed that relate to learnability of the software interfaces. It was important that, by the time the analysis of data started, a preliminary understanding of the meaning of data was shown. I studied all material vigorously and deepened her awareness by viewing the video recordings repeatedly, reading and re-reading all notes and interview transcripts.

2. Inducing Themes

Terre Blanche and Kelly (1999) point out that induction is the inference of general rules or classes from specific cases. It is meant to identify themes that exist within the data, using a bottom-up approach. Analysis goes beyond merely deducing a summary of the content, as it integrates the identification and investigation of processes, functions, tensions and contradictions that arise in the underlying data. The identified themes then form the basis from which the descriptions of the observations can be refined and reorganised accordingly.

As an example, one of the themes in this study was the sequence theme. That refers to the way the child, who was teaching another child a new application, explained the steps to be followed while playing. During analysis, all observations related to sequencing were collated for further analysis.

3. Coding

During the activity of developing themes, data should be coded. Miles and Huberman (1994, p.56) describe coding as an analysis where one reviews a set of field notes, transcribed or synthesized, and dissects them meaningfully, while keeping the relations between the parts intact. The notes are scrutinised to identify instances of specific themes, or relevance to specific themes or categories. These are coded in a way that links them to that theme or category. Codes, themes or categories need not stay fixed throughout the coding and analysis process. New themes may emerge at any stage, or existing themes may be discarded based on newly acquired knowledge.

Strauss and Corbin (1998) discuss three distinct yet overlapping processes of analysis involved in grounded theory from which sampling procedures are typically derived, which are similar to coding explained above. These processes are: open coding, axial coding and selective coding. Open coding is based on the concept of data being 'cracked open' as a means of identifying relevant categories. Axial coding is most often used when categories are in an advanced stage of development. Selective coding is used when the 'core category', or central category that correlates all other categories in the theory, is identified and related to other categories (Strauss and Corbin, 1998).

In this research, data observed from the videos was combined into themes, ideas and categories. Similar data was marked with the code text and specific themes were recorded.

4. Elaboration

Elaboration involves exploring the newly organised material to identify similarities and differences in the data that may lead to new insights – insights related to the difference between adults' and children's ways of learning. The accrued material resulting from analysis and coding is reorganised and arranged into a coherent discussion of learnability.

The outcome of elaboration in the present study will be a reformulated definition of learnability.

5. Interpretation and Checking

The final account of the study is given in this phase. There is need to ensure that no weak points, contradictions or holes in the proposed framework were given. Problems such as over-interpretation of trivial matters or parts which were obviously led by the researcher's prejudices, should be identified and corrected.

I found a close relationship between the steps above and steps for qualitative analysis described by Siedel (1998). Siedel says that analysing data is a process which consists of three parts as shown in the Figure 3.8 below:

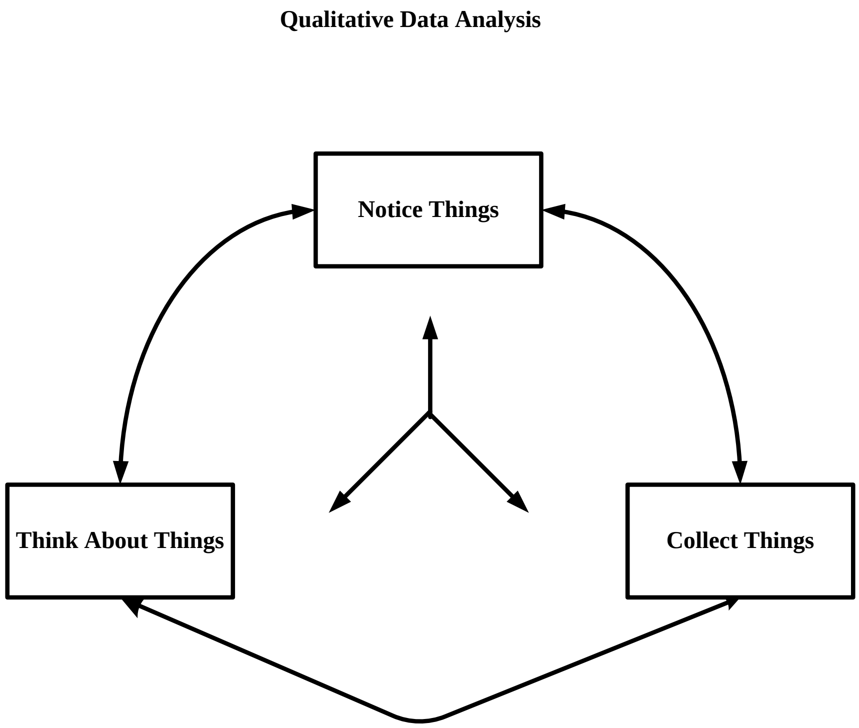


Figure 3.8 Diagram adapted from Siedel (1998)

'Noticing things' is the type of analysis where breaking up, separating, or disassembling of research materials into pieces, parts, elements, or units is done. In this research, the videos taken in the usability laboratory of experts teaching novices new software applications, and of novices teaching themselves, were analysed. The semi-structured interviews were used. When this was done, attempts were made to produce a record of the things that were noticed and this was done through coding. It took several weeks to get the information required, with the coding process being repeated numerous times. Collecting occurs when facts are decomposed into manageable pieces, sorting and sifting them. When one identifies pieces, one is noticing and 'coding' them. When one sorts the pieces, they are being 'collected'.

In searching for types, classes, sequences, processes, patterns, or wholes, Jorgensen, (1989) says that the aim of this thinking process is to assemble or reconstruct the data in meaningful or comprehensible fashion. In this research, after sorting the data pieces into groups, individual pieces were inspected to determine how they fitted together and form smaller parts of the picture. In the thinking process, information collected was examined. The goals were: 1) to make sense out of each collection; 2) to look for patterns and relationships both within a collection, and also across collections. It was difficult to find lots of patterns; and 3) to make general discoveries about the research phenomena (Siedel, 1998).

3.6.4 Summary

In summary, three research techniques, sampling, data collection methods and data analysis have been discussed in the above subsections. As it is not possible to make direct observations of every individual in the population one studies, it is important to collect data from a subset of individuals, a sample, and use those observations to make inferences about the entire population. As has been mentioned before, one goal of scientific research is to describe the nature of a population, a group or class of subjects, variables, concepts and phenomena.

In this research all the data recorded was collated in a table during the testing phase. Common trends and patterns across the sample size were then investigated. Common problems that participants faced during the observation, and what they found easy and interesting to do, were identified.

3.7 Validity and Reliability

Validity and reliability are two factors that any qualitative researcher should be concerned about while designing a study, analysing results and judging the quality of the study (Patton, 2001). These factors can be approached through careful attention to the research's conceptualization and the manner in which the data is collected, analysed and interpreted as well as the way in which the findings are presented (Merriam, 1998). Reliability and validity are important in all research and address issues about the quality of data and appropriateness of the method used. In my study I used both qualitative and quantitative research for triangulation purposes. Golafshani (2003, p.603) defines triangulation "as a strategy (test) for improving the validity and reliability of research or evaluation of findings".

3.7.1 Validity of Measurement Instrument

Validity is the degree to which a research instrument measures what it is intended to measure (Creswell, 2009; Joppe, 2000 and Charles, 1995). It adheres to the notion that consistencies with which items are answered remain relatively the same. In this study, a pilot study, which is a smaller version of the study, was carried out to obtain information and to assess the feasibility of the study. The participants in the pilot study were similar to those in the main study. Both the pilot and main studies were done under similar settings. Conducting a pilot study assisted in identifying problems which could be encountered in the actual study and to correct these. In the main study different combinations of users were used in the experiments. Adult experts were observed teaching either a child novice or adult novice and vice versa.

One of the measurement instruments that were used in this study was the eye tracking system. It was used to measure eye fixation on particular areas of an application. On the eye tracking system, fixation is denoted as an area that occurs when our foveal attention lingers on a particular object. The larger these areas are, the greater is the fixation. The question that must be asked in order to answer the validity question is whether or not the eye tracking system faithfully represented areas of user fixation. One answer to this question is based on an assessment of calibration error, which is beyond the scope of this study. However, it can be assumed that, if the eye tracking system operates within its calibration limits, the fixation data that it presents to the researcher is a faithful representation of actual fixation patterns, which renders the measurement instrument valid. The set-up in the laboratory, which separates the observer from the observation area, reduced the tendency of participants to fake their behaviour which can occur when participants know that they are under intrusive observation. This improved the validity of observation results.

3.7.2 Reliability of Results

According to Polit and Beck (2004, p. 730), "reliability is the degree of consistency or dependability with which an instrument measures the attribute it is designed to measure". It is the extent to which a test or procedure produces similar results under constant conditions or on all occasions when administering the test some time after the first, or where equivalent versions of the same item are given and results correlated. Leedy and Ormrod (2010) allude to the above when they say that the reliability of a measurement instrument is the extent to which the instrument yields consistent results when the characteristic being measured has not changed. In this study, after the observations and video recordings, informal, semi-structured interviews were carried out. The use of interviews on all participants increased the consistency of the information collected. Four different software applications were used with different combinations of users in the experiments. This was to ensure that consistent results would be obtained, independent of the combination of participants involved.

3.8 Ethical Considerations

It is the responsibility of the researcher to ensure that ethical standards are adhered to. An ethical clearance exercise was conducted to ensure that my study had research integrity embodying a range of good research practice (Miles and Huberman, 1994) and conduct, including intellectual honesty, accuracy, fairness, and protection of human participants involved in the conduct of research,

3.8.1 Permission to Conduct Study

Firstly, I obtained permission to conduct the study from the relevant authorities. The request for permission to conduct the study was forwarded to the University of South Africa (see Appendix C), and permission was granted (see Appendix D).

3.8.2 Informed Consent Forms

Information documents and informed consent forms were sent to parents of the children who were going to participate in the research, to grant their children permission to participate in the experiment (see Appendix E). Adult participants were also given information and consent forms to sign which stated that they were agreeing to participate at their own free will (see Appendix F). It was very important for participants to know and remember that the study was investigating the learnability of software applications and that, if they, as participants struggled, that it would indicate where the software was lacking. It would not mean that they were doing anything wrong. Other main ethical considerations included the researcher making sure everything was ready before the participant arrived, and informing the participant about the state of the system and of the confidentiality of the results (Nielsen, 1994).

3.8.3 Confidentiality and Anonymity

Confidentiality was assured by restricting access to the gathered data only to me, the researcher and supervisors. Participant anonymity was guaranteed by not using actual names of participants in the study.

3.8.4 Privacy

Privacy refers to the right that all information collected in the course of the study will be kept in the strictest confidence (Polit and Hungler, 1999). In the study the participants were informed that they could behave in any way and that this would remain private.

3.9 Conclusion

This chapter focused on how data was collected, what research instruments were used, a description of the sample and finally an explanation of the empirical investigation that was followed. Appendix H provides details of the participants` responses to the interview questions.

The next chapter gives a comprehensive description of the data analysis and findings from the data collected through various data collection methods used.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

Chapter 3 discussed the research design and methodology of this study. The current chapter presents the results of the data analysis. The purpose of this research was to compare the meaning of the learnability principle for children and adults. Answers were sought as to whether or not the learnability of software interfaces had a different meaning for children and adults. The results of the experiments gave valuable information regarding aspects of the learnability of software interfaces that adults and children approach differently. These findings are termed 'insights' and ten insights are discussed in this chapter. The knowledge gained through this research will help software designers to improve the learnability of their products by distinguishing between the needs of users in different age groups.

In this chapter, I discuss the data analysis and its interpretation. The chapter will accordingly be organised as follows:
In Section 4.2, I discuss the data structure. In Section 4.3, I discuss the analysis and interpretation of data from the experiments done. I conclude the chapter in Section 4.4.

4.2 Data Structure

In Chapter 3, a three-stage data collection process was discussed. The bulk of the data came from stage 2 that involved observation and video recording of participants in the usability laboratory. During data analysis I scrutinised the data while keeping in mind the guiding question: Does the learnability of software interfaces have a different meaning for children and adults? The data collection and analysis process was done in accordance with the steps proposed by Terre Blanche and Kelly (1999) and Siedel (1998) (as discussed in section 3.6.3).

Familiarisation and immersion

For each type of software application, I viewed and transcribed video recordings of the participants interacted with each other and with the software. The transcribed data was organized as shown in Table 4.1 below, which contains no data, but is given as an example of template used (see Appendix G for complete tables). The column labeled 'Software' captured the name of the software, whilst columns 'Expert' and 'Novice' captured, respectively, video recording data of what the expert and novice participants said and did.

Table 4.1 Organisation of video recording data

Software	**Expert**	**Novice**
Timez Attack	CE_1	AN_4
Microsoft Outlook	AE_6	CN_7

Over a period of two months, I first recorded activities in a notebook before transferring the notes onto computer. This process required repeated viewings of all the recordings. Refer to Appendix G for the full transcription of video recordings.

Inducing themes/Noticing things

I went through the recorded activities and broke them up into separate units. The following headings were used:

- How an expert taught the novice (e.g. how they proceeded and what elements they focused on),
- How the novice learnt (e.g. what they struggled with, whether they asked for help),
- How the novice played games (e.g. what they did first and how they proceeded with game play),
- The reaction of the novice to interface elements (what excited them or what frustrated them).

These categories were then developed into themes. Refer to Appendix H for the units created.

Coding/Collecting

Notes were encoded in a way that linked them to specific themes. The things that belonged together were grouped, but there was data that did not fit clearly with any of the themes. Some themes were discarded if they did not help in the acquisition of any insights, but some were kept aside in case they would be needed later. New themes that emerged were added. Appendix H provides more detail on the encoding process.

Elaboration

I explored the newly organised material to identify patterns in the data that could lead to new insights related to differences in the learning styles of adults and children. The themes resulting from analysis and encoding were then re-organised and re-arranged into a coherent discussion. Here, the focus was on the following subquestions:

- With which aspects of software interfaces do children and adults struggle?
- With what aspects of software interfaces do adults and children respectively have no problems and find engaging to do?
- What differences are there between children and adults in their emotional reaction to interface elements?
- What information does eye-tracking provide regarding differences in the behaviour of adults and children, when learning to use an unfamiliar computer game?

As an example, Figure 4.1 shows extracts from the elaboration process on data related to the e-mail application when used by an adult novice (see Appendix H).

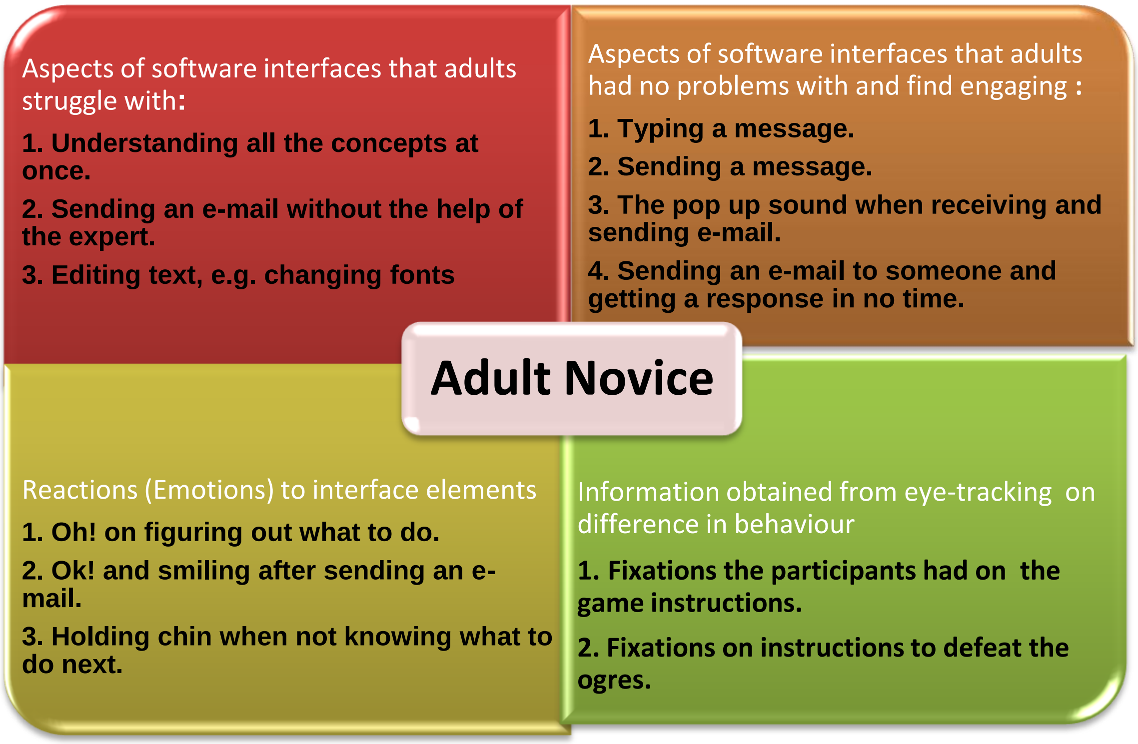


Figure 4.1 Extract from the elaboration process

Interpretation, Checking and Thinking about things

After elaboration, I looked for patterns and relationships both within a collection, and also across collections (Siedel, 1998). Patterns were discovered in the learning behaviour of adults and children. These patterns were then formulated into insights which highlighted the differences in how children and adults learnt to use software applications. From the insights and corresponding evidences, the implications for design were formulated.

4.3 Data Analysis and Data Interpretation

While the main method of data analysis was qualitative, some quantitative data analysis was also used in a mixed methods approach (Creswell, 2009). Quantitative methods provided some triangulation whilst qualitative methods allowed for in-depth information to be obtained. Qualitative methods helped in generating rich, detailed data that provided insights into the differences in the learning styles of children and adults. The qualitative data analysis is discussed next.

4.3.1 Qualitative Data Analysis

This section is organized according to the insights that emerged from the elaboration process. The insights provide some information regarding the learning style differences which were noted as the participants used the four software applications. The insights are discussed together with their justifying evidence, as well as the possible implications for software application design. The implications are intended to help software application designers to improve the learnability of their products by distinguishing between the needs of users of different age groups.

Insight 1

Children are more accepting and accommodating of usability problems than adults.

Evidence

Reaction to congratulatory message in the Timez Attack game

At the initial stages of the Timez Attack game, a congratulatory message incorrectly appears on the screen before the player has actually achieved any milestone in game play. Figure 4.2 below shows this message.

Figure 4.2 Incorrect placement of milestone message

The children ignored the message. They just waited for the message to disappear in order for them to continue with game play. However, when the same message popped up while adults were playing, they questioned why they were being congratulated before completing a task.

Selecting an object in StoryBook Weaver

When playing StoryBook Weaver, children did not appear to be frustrated when they discovered that they had to select and add an object by clicking on the (+) button instead of the expected (√) button, as shown in Figure 4.3 below.

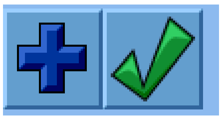


Figure 4.3 Buttons for selecting and adding objects

Children clicked on both buttons in an attempt to figure out the right one. Adults, on the other hand, appeared irritated when they did not get the desired outcome by clicking a tick (√) instead of a plus (+) to add an object on the picture screen. Words and actions that were used included the following:

AN_{13}: Clicked the (√) button repeatedly.

AN_{13}: Showed a frowning face, when repeatedly clicking the tick (√) button did not yield the expected outcome.

AN_{15}:"I am completely baffled and whatever this is, it is non-intuitive…".

AN_{15}: Shaking his head sideways with disbelief and also holding his chin.

AN_{8}: "What stage should we go to next?"

AN_{10}: "Oh Good Grief! What must I do with this thing?"

AEN_{3}: "What must I do now?"

AN_{14}: "What do I write now?"

Implications for Design

Designers should not assume that a child's impression of usability is valid. They can be very forgiving and may not comment on obvious problems when asked their opinions. It may be a good idea for designers to test products intended for children with adults in order to discover any potential usability problems that may be overlooked when testing with children.

Insight 2

Children and adults use different learning techniques when playing an unfamiliar game. Adults rely on instructions and are more systematic than children in how they approach learning a new application. Children are more willing than adults to use trial-and-error to achieve an objective.

Evidence

Focus on different buttons by adult and child participants

As the participants started playing one of the educational games, Timez Attack, children were more willing than adults to try out different buttons. When eye tracking was used to record areas of fixation whilst children and adults taught themselves how to play the computer game, it was seen that children immediately searched for the button that would activate the game. Eye tracking results showed that the longest fixations of child novices were on the Play button at the top of the screen. The size of the circle in Figure 4.4 below reflects the length of the fixation and the numbers indicate the order of fixations. Adult participants fixated on the instructions at the bottom of the screen, as shown in Figure 4.5 below.

Figure 4.4 Longest fixations of child novice on opening screen

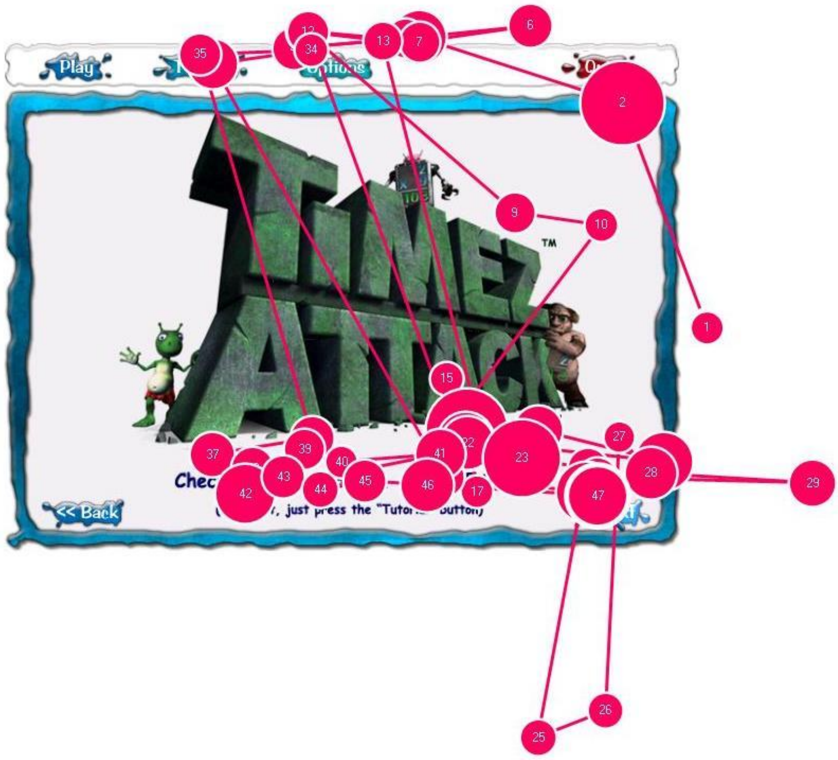


Figure 4.5 Longest fixations of adult novice on opening screen

Implications for Design

Designers of software intended for children should not rely on written instructions to inform children how to use the software. They should use elements of predictability to make the software easy to use without instructional guidance. Children learn through trial-and-error and are not scared to experiment to find out what would happen. This means that children's products must be more robust and fault tolerant. However, predictability is also important for children because if they use trial-and-error and do not succeed, they may lose interest. Adults are more systematic than children in the way in which they learn to use a new software application. Therefore user interface designers should be particularly aware of elements of predictability in user interfaces of applications designed for adults. For example, software designers should provide operator instructions for software designed for adults.

Designers should also make the instructions clearly detectable and well positioned on the screen, so that users can more easily find and read them. Children are interested in just playing the game. If designers require application users to read instructions, these instructions should appear at an early stage. Instructions also need to be brief, especially in the middle of a video game where users need to concentrate on game play. Users are interested in the graphical elements, game play and interaction; not in reading lengthy instructions.

Insight 3

The life experiences of adults are vaster and more diverse than those of children. Adults tend to have fixed patterns as a result of their life experiences and can be less open-minded during learning than children. Children, on the other hand, learn in an *ad hoc* (unplanned) manner, with less reference to life experiences.

Evidence

Fixed patterns as a result of life experiences

Adult novices had difficulty using the mouse and keyboard for Timez Attack game moves because they were accustomed to using the mouse for clicking buttons on menus rather than moving objects from one place to the other. They could not adjust to using the mouse for anything else (e.g. a steering device). Children had very few problems with this. They tried different game moves, clicking on every button just to see what would happen. In StoryBook Weaver, both children and adults had problems with the user interface once they started using it. Adults became very frustrated, because it took time for them to grasp the idea that when they wanted to apply a user action in

StoryBook Weaver, they had to click (+), and not the (√). They understood a plus or cross icon as meaning NO or ‘do not apply’. They would have preferred a tick, which means YES, to apply a user action. Even though children were also confused with the use of (+) instead of (√), they quickly adjusted to the intended usage. Children did not appear to be frustrated when they discovered that they had to select an object and click on a (+) instead of the expected (√).

Past experience

Whilst demonstrating to the novices, the adult expert gave examples of similar things:

> AE_1: “An e-mail carries the same principle as sending an sms on a cell phone, or writing and posting a letter via the post office. The only difference is that this is done electronically”.

> AEN_5: “An e-mail program is like a two-way thing, you send and receive e-mails, just like a Post Office, you receive something from the post box and you also send letters”.

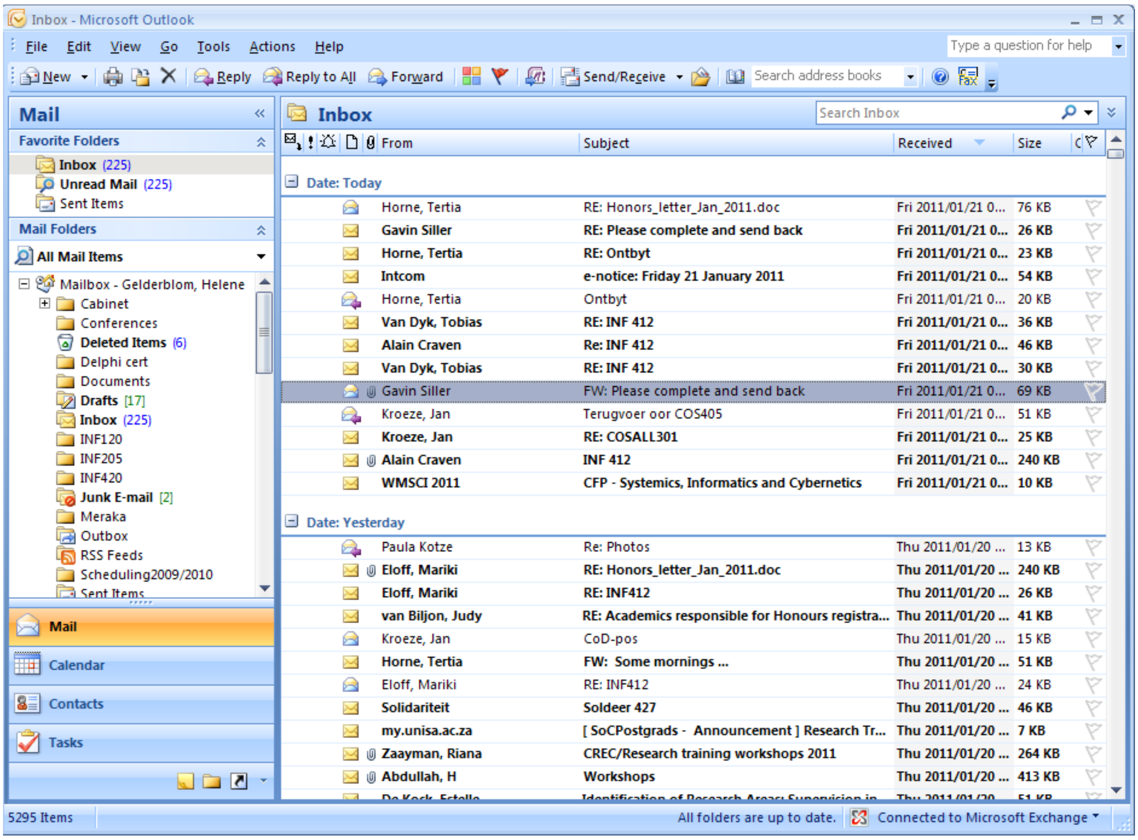


Figure 4.6 An example of an e-mail

Implications for Design

The above evidence is an indication that the system should offer the same or similar functionality in comparable situations, and in a familiar fashion. Similar actions should yield similar responses. It is therefore expected that the similar components look alike and respond similarly to user input. Designers should maintain consistency of style within the software because it supports user fluency. For example, buttons for save, help and exit should appear in the same location on each screen. This consistency of style is also important for users who need to use alternative input methods and for those who have learning difficulties.

Software designers should design software applications that accommodate the different learning styles of different age groups. For example, there is a need to accommodate the less instruction-dependent children. Designers should accommodate the different life experiences of users and encourage all age groups to explore and discover other ways of doing things.

Insight 4

Children learn to use a new software application more independently than adults.

Evidence

Call for assistance during play

Child novices rarely asked for assistance during game play. They discovered things for themselves without any need for guidance. Their natural curiosity drove them to make new discoveries. They were also quick learners. Adult novices asked for help the moment they were given the chance to play the game. Some of the questions they asked were as follows:

AEN_3: "What must I do now?"

AN_{14}: "What do I write now?"

AN_{14}: "What am I going to say?"

$AEN_{3:}$ "Do I still not give the answer?"

AN_4 and AEN_3: "Where am I now?"

AN_2: "How did you throw the creatures?"

AEN_3: "How do I get the key?"

AEN_5: "What if I just type the answer without throwing first?"

> AN_{11}: "How do I know that I can immediately type the answer?"
>
> AN_{11}: "How can I move the avatar to the left?"
>
> AN_{10}: "What is the mouse doing?"
>
> AN_{10}: "What must I do with this thing?"

Adults were hesitant to try anything independently. They needed to be told what to do in order to do something. They asked many questions and also asked for help. They consulted throughout the demonstration of the software application by an expert. Examples of questions asked:

> AN_9: "When I choose the font size, how do I know that I have chosen the right font size?"
>
> AN_8: "What is the difference between a slide show and animation?"
>
> AN_8: "How do you get the Custom Animation?"
>
> AN_8: "How do I size the picture?"
>
> AN_9: "Is it possible to print slides?"
>
> AN_9: "Can I also click from word and paste it onto my slides?"
>
> AN_7: "Can we do it together again then l can later do it on my own".
>
> AN_8: "What is written under design?"

Implications for Design

Software intended for children should include elements that facilitate independent learning. Software designed for adults, on the other hand, should provide detailed instructions on how to use the application. Adult application users must always have access to easy or clear Help/Instructions.

Insight 5

Child novices are faster than adult novices in gaining and mastering mouse and keyboard navigation skills during game play.

Evidence

Mouse/keyboard navigation

In Timez Attack, all the adults struggled to use the mouse/keyboard combination to walk the avatar through the dungeons. During game play, adults dragged the mouse in all directions and did not exactly know the directions they were supposed to take to get the avatar moving successfully. Examples of the emotional expressions of adult novices in reaction to mouse/keyboard navigation difficulties included the following:

> AEN_3: "Oooooooooohmmmmmm!! What now?"
> AN_{10}: "Oh man, what is the mouse doing?"
> AN_{10}: "Oh Good Grief! What must l do with this thing?"
> AN_{12}: "Good Lord!" Raises his hands and laughs.
> AN_4: "I give up!!"
> AN_{11}: Scratching head and saying "Oh my" and laughing.
> AN_{12}: Would laugh at himself whenever he failed to move the avatar with the mouse.

Children displayed more dexterity than adults in using the mouse to navigate characters. Out of the seven child novices who learnt how to play Timez Attack, only one experienced difficulty navigating characters with the mouse during the initial stages of the game, but improved at the end. When CEN_3 failed to navigate, she sighed and said, "I feel so stupid". In this game, child novices demonstrated better mouse and keyboard skills than adults. Child novices found it easy to turn avatars by using the mouse and to make them walk with arrow keys. The children did this very fast, and were quicker than adults in giving answers to multiplication tables questions. When moving the avatar using the mouse, child novices showed better hand-mouse coordination than adult novices.

Adult novices struggled to move the avatar throughout the game and only managed to do so with the help of the experts. They asked for help the moment the game started, but child novices started playing without the help of the experts. It was difficult for adults, with five out of the seven who played the game struggling until the end of the game. This could have been mainly because adults do not have experience in using the mouse for game moves, but rather for clicking buttons or links. Timez Attack uses the mouse/keyboard combination in a way that is not consistent with other applications that adults use.

Implications for Design

Designers of software applications should match the user interface controls to the ages of the different users. For example, if adults find it difficult to coordinate the simultaneous operation of the mouse and the keyboard, software designers should rather design one type of the preferred control. Designers should therefore design software that encourages all age groups to develop their motor skills. If software is designed for all age groups, perhaps software designers should provide customisable user interfaces that enable users to customise the user interface controls to match their preferred style of control.

Furthermore, designers should not assume that because adults generally have better hand-eye coordination than children, that they will be better than (or just as good as) children at navigation.

Insight 6

Adults want to have a clear picture of the entire software application before they start using the application, whereas children just start using the application.

Evidence

Background on software application

The above insight is evidenced by how adult experts taught the novices. The adult expert began by asking the novice if they knew anything about the application. They then briefly demonstrated a complete product, for example of Outlook or PowerPoint presentation. The adult expert then explained what the software was about, before giving instructions for using the application and demonstrating it practically. Whilst demonstrating, the expert would ask questions of the novices as a way of checking whether they understood these demonstrations. Examples of adult expert-novice interactions were as follows:

> *PowerPoint Application*
>
> AEN_3: She first displayed a completed slide of a PowerPoint presentation prepared beforehand.
>
> AEN_3: “This is what it will look like at the end. So that is what we are working towards”.

Outlook Application

$AEN_{5:}$ "Before we start, do you understand what an e-mail is and what it does?"

AEN_5: "What I am going to do is show you what an e-mail looks like and how it works".

AE_1: "This is what our e-mail system looks like. These are all messages received".

AE_1: "Now I need to show you how to write and send an e-mail".

The child expert instructed novices on how to use the software applications for the first time. The child expert allowed the novices to learn the applications by participating from the start. Examples of child expert and novices interations were as follows:

CE_1: "Now you must enter the subject. So what subject should I write for you?"

CE_1: "You can click on it and format it".

CEN_8: She demonstrates how one can send an e-mail.

CE_5: "Choose the object you like and click on the (+) button".

CN_6: "I can choose? I like that one".

All the adult participants began by reading the tutorials of Timez Attack and StoryBook Weaver while only one child participant read the Timez Attack tutorials. This shows that adults want a clear and complete picture of what is coming.

Implications for Design

Application designers should provide appropriate guided tours of the application for first-time users. Since children prefer to get on with it, without having to read lengthy instructional guides, designers should provide animated demonstrations of applications intended for children. If there is a chance that adults will use the product, tutorials that give a product overview should be provided, as adults prefer to read instructions before using the application for the first time. If both children and adults are expected to use the application, designers should provide customisable guided tours of the application in order to accommodate the requirements of both types of users.

Insight 7

Children do not mind trying out things just to see what happens. They do not expect things to go wrong. Adults are more cautious, and tend to be more self-critical than children. Adults are rigid in what they expect of a user interface, whereas children like to explore.

Evidence

Trial-and-error by children versus cautiousness by adults

In the Timez Attack game, snails have to be eliminated first before one can do multiplication tables. The process of locating the snails follows a set sequence of mouse moves. When child novices were playing the game, they moved the mouse at random, coming across the snails in the process, and eliminating them. In StoryBook Weaver, child novices started by moving the mouse around and clicking on buttons at random without following any clear pattern. Through a process of trial-and-error, child novices developed game play ideas or approaches which would give them the desired results. This process of trial-and-error deepened the abilities of child novices to play the game or use the software applications.

Evidence of the above insight is derived from the questions asked by the children:

> CN_3: "Does it matter which numbers I use on the keyboard?"
>
> CN_3: "Can I go the wrong way and see what happens?"
>
> CEN_{10}: "I want to see what happens if I do not catch one of the snails?"

Adults were more cautious than children in learning a new application. Cautiousness, as Salthouse (1991, p.176) points out, is "one of the most frequently mentioned perfomance-limiting factors". Adult novices hesitated to make any moves that they were unsure about. In all the software applications demonstrated, adult novices sked many questions. Some examples of questions and comments by adult novices were as follows:

> AN_2: "What if I click the wrong door?"
>
> AN_4: "I cannot figure out where he was".
>
> AN_{11}: "How do I make the avatar walk to the left without making a mistake?"
>
> AN_{12}: "What if I make a mistake and fall in a dungeon?"

Implications for Design

Applications designed for children should show greater tolerance for incorrect operation than applications designed for adults. Designers may work through a risk assessment to ensure the applications and their implementations do not expose children to unacceptable risks. If a game/application requires a very specific sequence of actions, the interface should make this clear so that children do not follow the wrong trail.

Insight 8

When learning to use a new software application, children are more comfortable learning from their peers than from adults. Adults, on the other hand, are not affected by the age of the person who teaches them, as long as the person demonstrates clear knowledge of what he/she is doing.

Evidence

Learning from peers

Child novices appeared very relaxed when they were being taught by a child expert. The children frequently interrupted the demonstrations with questions. For every move or action by the expert, a novice child would ask a question, for example:

CE_3: “Click What are those bars for?”.

CE_1: ”Yellow bar: How much time you have taken”.

CE_1: “Red bar: How much time you have left”.

CN_3: Asks if there is a time limit on the appearance of the bars.

CE_1: Is not sure, but says probably 5 minutes.

CE_1: “When you catch the snails it usually tells you the answer of the multiplication table on display”.

CN_3: What if you run out of time?

During informal semi-structured interviews, when asked how they felt working with their peers, all the children said that they felt confident and relaxed. When an adult expert was teaching, the children showed signs of intimidation by failing to ask questions as they did when they were being taught by a child expert. One of the children who asked a question to an adult expert only did so when the adult expert inquired if he had any questions.

Implications for Design

When developing training materials for software applications, designers should be aware of the effectiveness of peer tutoring for children. For example, where voice-overs are used in automated demonstrations of software designed for children, it would be advisable for software application designers to use a child's voice. Where animations are used, it would be advisable to use characters that children easily relate to.

When applications are developed for use in a school laboratory or in any situation where adult supervision will be present, the design should not presume that an adult will provide help when required. When struggling, the children may not ask for help spontaneously. They may rather try to get by on their own or they will ask their peers.

Insight 9

Children appreciate interactive demonstrations, especially if the expert teaching them is a child, as opposed to one-way demonstrations with which adults seem comfortable.

Evidence

In the demonstrations, novices were involved from start to finish. These are some of the things they asked or were asked to do:

Timez Attack

> CN_3: "Does it matter which numbers l use on the keyboard?"
>
> CE_1: "It does not matter, but you are more comfortable using the ones on the right hand side".
>
> CN_3: "How many times do they ask you to do times table each time?"
>
> CE_1: "Every time it asks you three times. To open the door it asks you once then when the monster is there it is three times".
>
> CN_3: "Can you go the wrong way?"
>
> CE_1: "You just go the other way".
>
> CEN_2: Looking at the red bar she shouts, "I know what it means; if you get the answer wrong then it shows the red line".
>
> CN_3: "I can see that the times tables get harder at the next stage".

StoryBook Weaver

When child experts demonstrated how StoryBook Weaver was played, they solicited the preferences of the novices, e.g.

> CE_5: “Choose the object you like and click on the (+) button”.
>
> CN_6: “I can choose? I like that one”.
>
> CE_5: “Which animal do you want me to take?”
>
> CN_6: “The unicorn”.

PowerPoint

> CE_1: “OK choose a design you like”
>
> CE_1: “Choose a title which I should write?”
>
> AN_8: “Mm, can you first show me how it is done?”

Implications for Design

Designers are encouraged to develop instructional demonstrations for children’s games that take full advantage of the needs and preferences of that user group. This includes the use of interactivity and animation. The use of cartoon characters for animation in an instructional demonstration may draw the full attention of children. Where voice-overs are used in demonstrations, children appreciate listening to another child’s voice, in line with this user group’s preference for peer tutoring. Designers are also encouraged to embrace elements of interactivity that allow children to actively take part in the demonstration and to control the pace and progress of the demonstration.

Insight 10

Children accept what they are learning regardless of its purpose. Adults find learning to be purposeful if it has meaning and adds value to their lives.

Children and adults get more involved if they are using software that relates to them. Adults connect their learning of new software applications to life experiences that may include work-related activities, family responsibilities and even previous educational experiences.

Evidence

Relevance to way of life

Adult experts gave a great deal of information on software applications such as Outlook and PowerPoint, because they were more well-versed with the software than they were with educational games such as Timez Attack and StoryBook Weaver. Adult novices showed great enthusiasm learning the former applications since they knew that these would help them in their day-to-day work. Child novices enjoyed the experience of using any of the software applications they were taught. Adult novices were more eager to learn PowerPoint presentations and Outlook than they were to learn educational games.

Figures 4.7 to 4.9 show the kind of pictures that adult and child novices produced in StoryBook Weaver. Child novices produced pictures related to their fantasy worlds, whilst adult novices produced mature pictures related to their day-to-day work or social environment.

Figure 4.7 CN_6 story and picture

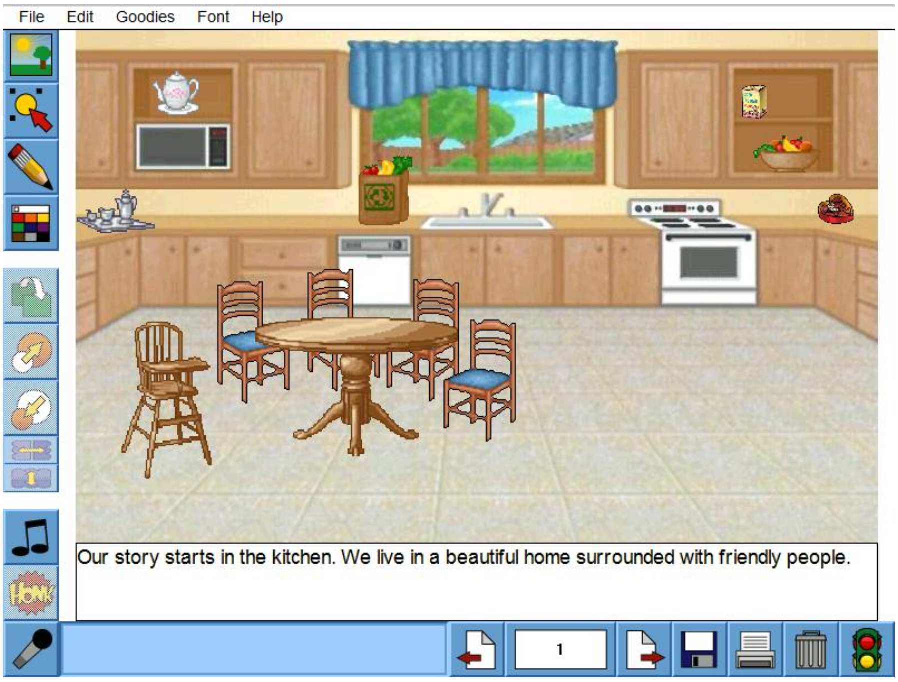


Figure 4.8 AN_{13} story and picture

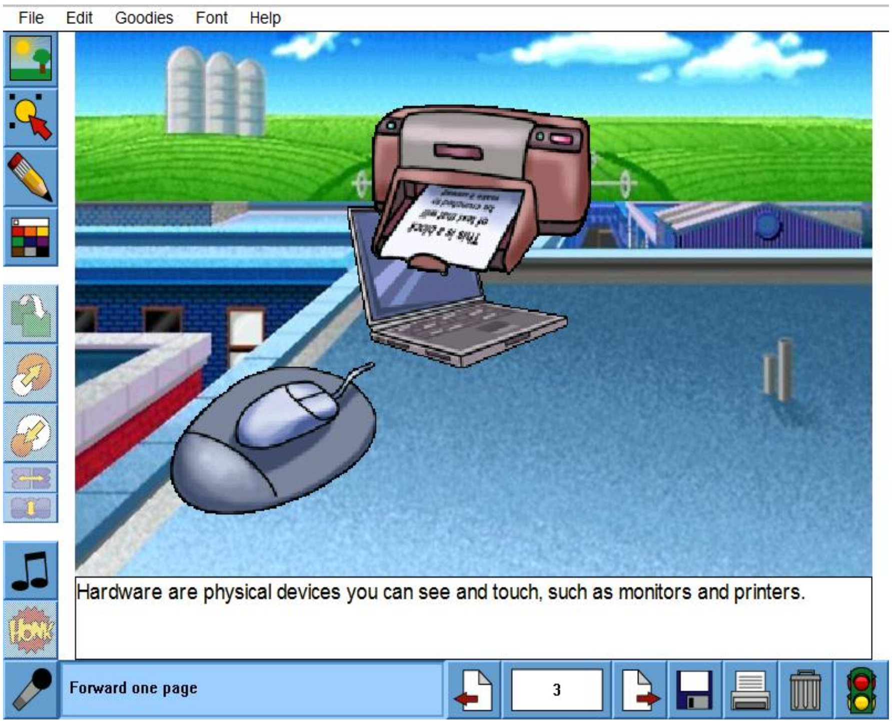


Figure 4.9 CN_{14} story and picture

Emotional engagement

Whilst the experts were demonstrating the two games, the child novices were paying very close attention to how the game was played. Adults showed more emotional engagement than children during their encounters with the software applications. Adults became easily frustrated when they were using an application that was not meaningful to them. Here are some examples of emotional expressions:

Holding cheek and scratching one's head and arms when failing to figure out what to do next.

Playing the game with a serious expression on their face.

"UHM!" When managing to open door.

Laughing throughout the game "Oh! Oh! Oh! Mmm!" when falling three times in a row.

Raising hands in the air, rejoicing after achieving an objective.

Talking to oneself.

"Sjoe! Ok what now?"

"Oh gosh - how now".

"Oooooooohmmm!"

"Oh finally".

Implications for Design

Adult learning is value-driven. Adult learners need to know why they should learn something before undertaking to learn it. Given the rationale for learning something, they will often invest considerable energy in investigating the increased benefits to be gained from the learning experience and the consequences of not learning it. Adults want to learn concepts that are related to a setting familiar to them, that they can use afterwards. Designers of software applications for adults should therefore make the value of learning a new application apparent to all adults.

Application designers should include elements of user interface design that reinforce positive emotions in the application user. For example, choice and autonomy of the individual in selecting elements of the application that help them to get engrossed in the application, can help with the application's acceptance. However, if the game could allow users to make a choice of elements with which to interact, potential users could possibly accept the game better.

Software application developers should design educational software which enables children to develop and practise a broad range of skills. It can help them learn, for example, about numbers, shapes, colours, and rhythm. Good software can also help children develop their understanding of cause and effect, higher order problem solving, procedural thinking, and creative expression.

This marks the end of the discussion of qualitative data analysis. Next, I discuss quantitative analysis of selected segments of the data collected. Quantitative analysis was used to provide some triangulation of the results of qualitative data analysis.

4.3.2 Quantitative Data Analysis

Quantitative analysis was conducted in order to gather more information on the differences between the learning styles of adults and children. The Timez Attack educational game was selected for this purpose because the number of participants that used it was sufficient to justify quantitative analysis of the data A total of 13 participants used Timez Attack. Two types of quantitative data were used:

1. Eye tracking data was recorded for 8 of the 13 participants.
2. The time taken (in minutes) to reach the first correct door, and the time taken (in minutes) to catch all the snails for the first multiplication sum, were logged from the video recordings for each user.

The results obtained from the quantitative analysis are not generalisable, but the emerging patterns are clear enough to indicate that they would also apply to settings other than those in which they originated.

4.3.2.1 Eye tracking (Fixations)

Fixations in first 20 seconds of the Timez Attack game:

To see whether participants read the instructions given at the start of the game, eye tracking data for the first 20 seconds into the game (see Table 4.2) was analysed.

Table 4.2 Fixations in first 20 seconds of the Timez Attack game:

Participant	Fixations on instructions	Fixations elsewhere in the game	Total fixations
CEN_7	9	38	47
CEN_8	18	18	36
CN_4	7	34	41
CN_{10}	5	38	43
AEN_5	46	14	60
AN_{10}	38	11	49
AN_{11}	22	62	84
AN_{12}	27	22	49

These observations show that adults had considerably more fixations on the instructions during the first 20 seconds of the game (Table 4.2). Figure 4.10, (Adapted from Pretorious, Gelderblom and Chimbo, 2010), illustrates the fixations of a child novice whereas Figure 4.11 illustrates the fixations of an adult. The child participants focused less on the instructions, while two of the adult participants had more than double the fixations on instructions (38 and 46) of the closest child participant with 18. The mean number of fixations on instructions was 9.75 for children and 33.25 for adults (Pretorious, Gelderblom and Chimbo, 2010). This suggests that the adult participants found instructions during game play more important at first, whereas child participants concentrated more on the game.

Later in the game the novices entered a part of the game where a great deal of movement was happening on the screen (e.g. creatures running around to be collected). Child novices paid little attention to the instructions when compared to adults during this stage of the game.

Figure 4.10 Child novice fixations.

The adults had considerably more fixations on the instructions during the first 20 seconds of the game.

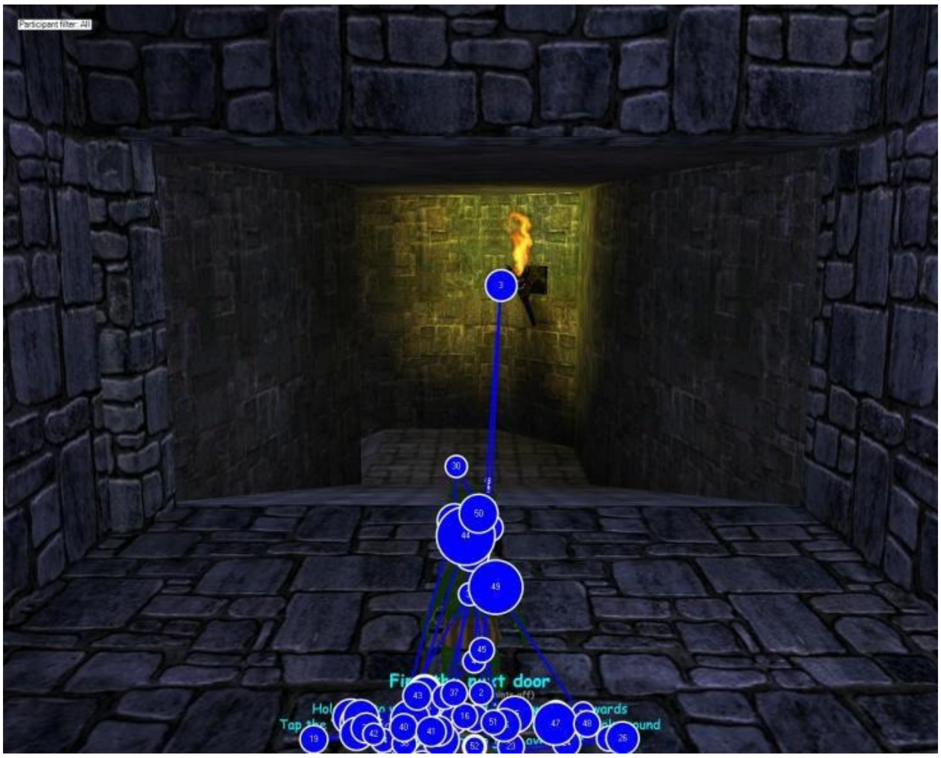


Figure 4.11 Adult novice fixations.

Pretorius, Gelderblom and Chimbo (2010) suggest that adult novices find instructions during game play more important at first, whereas child novices concentrate more on playing the game. While adults preferred to read instructions, children preferred playing the game through trial-and-error.

To see if participants read the instructions to collect the creatures when they reached a specific point, eye tracking data was captured for the first 20 seconds from when the instructions appeared. For this task, the child participants had very few fixations on the instructions (mean 3.25). See Figure 4.12 (from Pretorious, Gelderblom and Chimbo, 2010) below.

Figure 4.12 Fixations for a child

However, the fixations on instructions by adults decreased as well (mean 14.25). Gaze paths showed that none of the participants read the complete instructions. Figure 4.13 is an illustration of such an example.

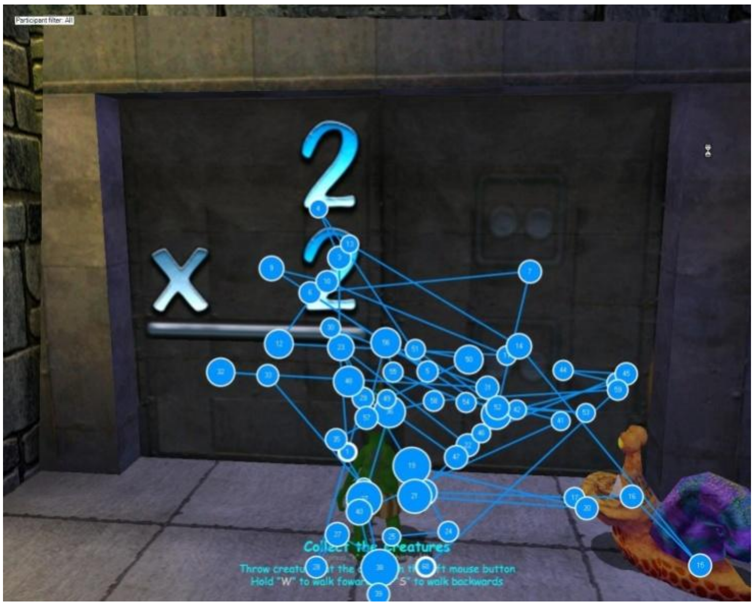


Figure 4.13 Fixations for an adult

When these instructions appeared, participants had just entered a part of the game where lively activity was occurring on the screen (the creatures running around to be collected). It was also not clear to the players that the instructions had changed from the previous instructions. Creature movements and the display of numerical data attracted the participants' attention away from the stationary instructions. Analysis of the video and audio data discussed below supports the findings from the eye tracking data in this regard. Generally, users struggled with this part of the game. It is therefore important that they should be made aware of the instructions. Moreover, designers should be aware of the pitfalls of combining instructions with points of on-screen activity.

Fixations on instructions to defeat the ogres

To see if participants read the instructions given when they had to answer the multiplication questions presented by the ogre, eye tracking data was captured for the first 20 seconds from when the instructions and the ogre appeared, or up to the time the ogre was defeated. Table 4.3 shows children having a maximum of one fixation on the instructions with adults having a maximum of 16.

Table 4.3 Fixations on instructions to defeat the ogres

Name	Fixations on instructions	Fixations elsewhere in the game	Total fixations
CEN_7	0	60	60
CEN_8	0	37	37
CN_4	1	35	36
CN_{10}	Switched off instructions	60	60
AEN_5	1	70	71
AN_{10}	10	47	57
AN_{11}	3	74	77
AN_{12}	16	46	62

Figure 4.14 Fixations on instructions by a child during the battle of the ogre

Figure 4.14 illustrates an example of a child participant with no fixations on the instructions and most fixations on the ogre (Pretorious, Gelderblom and Chimbo, 2010). As in the previous two tasks, this is a very interactive part of the game and the user is compelled to concentrate on the game. Again, shorter clearer instructions are needed. An instruction like "Type the answer" is displayed in 5 second bursts (on and off) three-quarters of the way up the screen if the user struggles.

The results described above indicate that there is a notable difference in the visual focus of adults and children when learning to play a game. As stated in Insight 2, adults need to read instructions during initial stages of the game, while children start to explore the game without consulting instructions. Children focus on the game elements and use a trial-and-error approach instead of reading on-screen instructions. Adults are more willing to interrupt game play to read the instructions.

What the discussion above indicates with regard to the learnability principle, is that when evaluating the learnability of an interactive game for children aged from 9 to 13, the presence of tutorials and text-based on-screen instructions should not be valued highly. For Timez Attack, the results have unfavourable implications: the user group for which it is intended, does not read the instructions in their current form and children do not use the tutorial that is available on the opening screen. This also has implications for console games that usually come with written instructions. Do children ever read these instructions before playing the game?

4.3.2.2 Comparison of response time

The eight participants tested, as indicated above, have provided valuable data and clear indications of differences in the learning behaviours of adults and children in game play. Since the conclusions are not generalisable, we need to combine these results with results based on the video, audio and interview data of these and other participants, as well as with the results on the other three software applications. It was necessary to use an experimental research design in order to determine whether there was a difference in performance between adults and children in terms of learning how to play a computer game. Two aspects of the game were timed: getting to the correct door and catching the snails. A small data set was used (see Table 4.4) and a test for normality was done to determine whether the data was normally distributed. The goal of the task was to check whether there was a difference between adults and children in the time it took to move to the correct door where they would do multiplication tables and how long it would take them to collect the creatures (snails). In the case where data was not normally distributed, non-parametric tests were conducted. Below are the results of statistical analysis done using 13 participants.

Table 4.4 Time taken to reach the correct door and catch the snails

Participants	Getting to the correct door in Minutes	Catching all the snails in Minutes
CHILDREN		
CN_3	01:00	00:24
CEN_2	00:57	00:51
CEN_8	01:23	00:44
CEN_7	01:41	01:25
CN_4	00:53	00:39
CN_{10}	00:56	02:58
ADULTS		
AN_2	02:25	03:46
AEN_3	01:51	02:34
AEN_5	02:06	03:59
AN_{10}	02:55	06:59
AN_4	03:32	01:18
AN_{11}	08:43	04:18
AN_{12}	06:28	03:23

Getting to the correct door

A test of normality was done to determine whether the time taken by participants to reach to the right door was normally distributed. The p-value for the Shapiro-W Wilk test is p=0.003 (see Table 4.5 below), which is statistically significant at the 0.05 level. Therefore, the data is not normally distributed for time taken to get to the correct door whilst the p-value for time taken to catch all the snails was 0.156, thus data is normally distributed. In this case the non-parametric tests were used for testing equality of means for time taken to get to the correct door whilst t-test was used for the variable time taken to catch all the snails.

Table 4.5 Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Time taken to get to the correct door	.251	13	.025	.768	13	.003
Time taken to catch all the snails	.174	13	.200*	.905	13	.156

a. Lilliefors Significance Correction

*: This is a lower bound of the true significance.

Comparison between adults and children on the time taken to reach the right door:

The average time taken by all participants to get to the correct door was 2.65 minutes. Since data was not normally distributed, a Mann-Whitney Test was conducted in order to determine the difference in the time taken by children and adults to reach the correct door. The mean rank for children was 3.5, whilst the mean rank for adults was 10. This implies that children took less time than adults, as indicated in Table 4.6 below.

Table 4.6 Ranks: Time taken to reach the correct door

Age level	N	Mean Rank	Sum of Ranks
Children	6	3.50	21.00
Adults	7	10.00	70.00
Total	13		

In this case the p-value of 0.003 for a two-tailed test was obtained as indicated in Table 4.7 below:

Table 4.7 Test Statistics[b]

	Time taken to get to the correct door
Mann-Whitney U	.000
Wilcoxon W	21.000
Z	-3.000
Asymp. Sig. (2-tailed)	.003
Exact Sig. [2*(1-tailed Sig.)]	.001[a]

a. Not corrected for ties.

b. Grouping Variable: Age level

*: Level of significance

The p-value = 0.003, which is statistically significant at the 0.05 level. This leads to the rejection of any notion that children performed the same as adults, thus children took less time than adults to reach the correct door.

Catching the snails:

In terms of the time taken by all participants to catch the snails, the test for normality showed that the data was normally distributed. A Shapiro-W Wilk test was done and a p-value of 0.156 was obtained (see Table 4.5 above). Thus, any notion that the data followed a normal distribution could not be rejected. In this case parametric tests were used.

Comparison of means:

The following group statistics were obtained:

T-Test

(The t-test assesses whether the means of two groups are *statistically* different from each other.)

Table 4.8 Group Statistics: Time taken to catch all the snails

Age level	N	Mean	Std. Deviation	Std. Error Mean
Children	6	0.9017	0.89491	0.36534
Adults	7	3.2714	1.67434	0.63284

It can be noted that children were faster in catching the snails with a mean of 0.90 minutes, compared to the adult mean of 3.27 (see Table 4.8 above). To find out if the differences were statistically significant, a T-Test was done to determine the difference in performance between adults and children. A p-value of 0.006 was obtained.

Table 4.9 Independent Samples Test

Time taken to catch all the snails	T-Test for Equality of Means		
	df	Sig. (2-tailed)	Mean Difference
Equal variances assumed	11	0.006	-2.60833
Equal variances not assumed	9.411	0.006	-2.60833

Since the p-value (0.006) was statistically significant at the 0.05 level (see Table 4.9 above), it follows that adults and children performed differently in the task of catching the snails.

Comparison of self-teaching versus those taught by experts

The mean rank for self-teaching was 8.00, whilst the mean rank for being taught by an expert was 5.83 (see Table 4.10 below).

Ranks

Table 4.10: Mann-Whitney Test:Time taken to get to the correct door

Participants	N	Mean Rank	Sum of Ranks
Self-teaching	7	8.00	56.00
Taught by an expert	6	5.83	35.00
Total	13		

In this case the p-value of 0.317 > 0.05 was obtained as indicated in Table 4.11 below:

Table 4.11 p-value

	Time taken to get to the correct door
Mann-Whitney U	14.000
Wilcoxon W	35.000
Z	-1.000
Asymp. Sig. (2-tailed)	0.317
Exact Sig. [2*(1-tailed Sig.)]	0.366[a]

a. Not corrected for ties

b. Grouping Variable: Participants

*: Level of significance

The p-value of 0.317 shows that there was no statistically significant difference in mean rankings between those who were taught by experts and those who taught themselves.

Relating the results to the differences between how adults and children learn in general, it emerged that, whereas adults usually depend on themselves in the learning process, they depend on the support of instructions more than children do when learning to use a game for children. There were also differences noted in getting to the right door and catching the creatures. Children catch snails and get to the right door faster than adults.

4.4 Conclusion

This concludes the data analysis chapter. The results indicate that there are differences in the way adults and children learn. With software applications related to educational game play, notable differences were encountered in the visual focus of adults and children when learning to play a game. Adults read instructions during initial stages of the game, while children started to explore the game without consulting instructions. Children focused on the game elements and used a trial-and-error approach instead of reading on-screen instructions. Adults were more willing to interrupt game play in order to read instructions.

A number of differences were also noted in all the software applications through the insights given above. To summarise, the following insights emerged:

1. Children are more accepting and accommodating of usability problems than adults.

2. Children and adults use different learning techniques when playing an unfamiliar game. Adults rely on instructions and are more systematic than children in how they approach learning a new application. Children are more willing than adults to use trial-and-error to achieve an objective.
3. The life experiences of adults are vaster and more diverse than those of children. Adults tend to have fixed patterns as a result of their life experiences and can be less open-minded during learning than children. Children, on the other hand, learn in an *ad hoc* (unplanned) manner, with less reference to life experiences.
4. Children learn to use a new software application more independently than adults.
5. Child novices are faster than adult novices in gaining and mastering mouse and keyboard navigation skills during game play.
6. Adults want to have a clear picture of the entire software application before they start using the application, whereas children just start using the application.
7. Children do not mind trying out things just to see what happens. They do not expect things to go wrong. Adults are more cautious, and tend to be more self-critical than children. Adults are rigid in what they expect of a user interface, whereas children like to explore.
8. When learning to use a new software application, children are more comfortable learning from their peers than from adults. Adults on the other hand are not affected by the age of the person who teaches them, as long as the person demonstrates clear knowledge of what he/she is doing.
9. Children appreciate interactive demonstrations, especially if the expert teaching them is a child, as opposed to one-way demonstrations with which adults seem comfortable.
10. Children accept what they are learning regardless of its purpose. Adults find learning to be purposeful if it has meaning and adds value in their lives.

The next chapter gives a comprehensive discussion on the findings from this chapter, relating it to the literature reviewed in Chapter 2.

CHAPTER 5

DISCUSSION OF THE FINDINGS

5.1 Introduction

The purpose of this research was to compare the meaning of the learnability principle for children and adults. The intention was to provide answers to the main research question of this study, which was whether or not the learnability of software interfaces had a different meaning for children and adults. The knowledge gained through this research is expected to help designers to distinguish between the needs of users in different age groups and to improve the learnability of their products.

This chapter discusses the findings from the previous chapter, relating it to the literature reviewed in Chapter 2. In Section 5.2, I will discuss the meaning of the learnability principle for children and adults and investigate how the literature on learnability principles is related to the insights from Chapter 4. I will also discuss the reformulation of the learnability principle. In Section 5.3, the learning process, which includes learning theories and skills development, will be discussed. Learning strategies will be addressed in Section 5.4. Section 5.5 provides some concluding remarks.

5.2 The learnability of software applications for children and adults

The literature review established that the learnability principle and the subprinciples associated with it encompass elements applicable to the learning processes of adults. It further revealed that the learnability principles can also be applied to products aimed at children. The main research question of this study relates to the possibility that learnability may have different meanings for these two user groups. I consider this in the discussions that follow, relating the principles to the insights gained through this study.

5.2.1 Predictability

The literature review established that a system would be easy to learn if it were predictable. Predictability is support for the user to determine the effect of future actions based upon a past knowledge of the system. In a predictable system, users are sure of what happens next and what they are allowed to do next. Predictability allows the user to know beforehand what will happen when he/she clicks on a menu item or presses a key. Insight 1, discussed in the previous chapter, shows for example, that children did not consider the meanings of the two buttons in Figure 4.3 as critically as the adults did. They merely tried them out until one worked, while adults experienced confusion, since the buttons did not function as they would have predicted.

The fact that adult novices struggled more to learn how to use Timez Attack can also be attributed to the fact that they rely more on predictability than children. For example, they expected the first door that they encountered in the game to be the door they should pass through, and would repeatedly try to get through the door. Children much sooner realised that they should search for another door. If something does not happen as they would predict, adults get frustrated. Children just move on in the game.

Elements relating to predictability were also evident from Insight 2. Children used trial-and-error to play the game, whilst adults read instructions first. Eye-tracking results showed that fixations of child novices were longest on the Play button whilst the fixations of adult novices were longest on the instructions. Adult novices had to read the instructions first in order to be able to predict the next game moves. Child novices used a trial-and-error approach, showing that they did not feel the need to predict the next game moves.

Insight 3 also refers to elements of predictability considering the way that adult novices used past experience to predict future actions. According to that insight, adult novices learn new things by relating them to past experiences, whilst child novices have limited past experiences to rely on.

5.2.2 Synthesisability

As explained in Chapter 2, synthesisability is the ability of the user interface to allow the user to construct a predictive mental model of how it operates (Hinze-Hoare, 2007). A user interface that adheres to the principle of synthesisability allows the user to understand which user actions have led to the current state, what the system did to get there, and what the user should expect next (predictability). According to Hinze-Hoare (2007), the user works out a framework or scaffolding for all the actions he can perform. For example, if the user moves a file from one folder to another, he should be able to check after the action is completed that the file is in the new location, as expected. This is what Dix et al. (2004) call the ‘honesty of the system’. Without this, the user would not be able to learn the consistent procedure for interacting with the interface.

Insight 3 relates to synthesisability. It refers to the life experiences of adult novices that are vaster and more diverse than those of children, and that allow them to develop fixed life patterns or mental models that may enable them to overcome the difficulties of learning to use a new software application. However, at other times, these fixed mental models may be detrimental to learning an unfamiliar software application. Adults tend to have fixed patterns as a result of their life experiences and can be less open-minded than children to new learning.

Insight 2 also relates to synthesisability in the sense that child novices, without much life experience to refer to in unfamiliar circumstances, work in a trial-and-error manner. They use whatever they learn in this way to construct cognitive maps of the workings of an unfamiliar software application. This is the essence of the principle of synthesisability.

5.2.3 Familiarity

The literature survey suggests that familiarity is the degree to which the user’s own real-world personal experience and knowledge can be drawn upon to derive insights into the workings of an unfamiliar system. The familiarity of a user with a system is a measure of the correlation between their existing knowledge and the knowledge required to operate the new system. To a large extent, familiarity impacts on the novice user’s initial perception of the system and on whether the user can therefore determine operational methods from their own prior experience. If this is possible, this greatly cuts down the learning time and the amount of new knowledge that needs to be gained. Schneiderman (1998) and Preece, Rogers and Sharp (1994) each refer to familiarity in terms of the reduction of cognitive load. When the new system is familiar, the user will relate it to similar systems or real-world situations, thereby reducing the cognitive burden to become truly adept at using the new system.

Insight 10 relates to familiarity. The insight discusses how child and adult novices get involved in learning a new software application if the new application relates to some tasks or activities that they encounter in real life. Adult novices felt comfortable working with software applications such as Outlook and PowerPoint because they were familiar with the productivity improvements that such software could afford them. Child novices preferred games such as Timez Attack and StoryBook Weaver to personal productivity software such as Outlook and PowerPoint, as they could easily relate games software to the playful and fantastical nature of their day-to-day existence.

Insight 3 also relates to familiarity. The insight suggests that adult novices learn best through applying past experiences in their learning, while child novices have limited life experience to apply in learning new things. The following observation of typical interactions support this view.

Users with previous experience of software applications in general, will experience similar functionality while using the new software and will find it easier to learn than users with no prior experience. The experiments showed that children mastered games faster than adults, because they had played other games with similar functions to the new games.

5.2.4 Generalisability

The literature survey suggests that a system is generalisable if users are able to use what they have already learnt to carry out new tasks (Dix et al., 2004 and Aspinall, 2007). A user interface that adheres to the principles of generalisability facilitates learning by novice users.

Insight 5 relates to generalisability. The insight suggests that child novices were faster than adult novices in mastering mouse and keyboard navigation skills. Besides youthful dexterity, as opposed to the general slowdown of motor co-ordination with age, the main source of performance advantage in mouse and keyboard mastery by child novices over adult novices could be found in the generalisability of mouse and keyboard skills mastered in the prior use of applications.

User interface standards and guidelines promote generalisability. A user who knows how to use specific icons in one application should be able to apply this knowledge in a different application. For example, font modifiers such as bold, italics, and underline, are typically used the same way in most applications. Insight 1 exemplifies this point. The insight implies that, for StoryBook Weaver, adult novices could not find the usage of (+) or (√) as displaying elements of generalisability, as they found the StoryBook Weaver usage of these buttons to be inconsistent with prior usage.

5.2.5 Consistency

Kristoffersen (2008) states that generalisability is sometimes described as a form of consistency, except that it applies more broadly to situations, rather than just operations. According to Dix et al. (2004), consistency relates to the likeness in behaviour arising from similar situations or similar task objectives. Consistency applies when the system behaves in the same way when comparable sequences of actions take place in similar situations. Consistent interfaces are easier to learn and use (Preece, Rogers and Sharp, 2007). They assist users in gaining more confidence in using the system and encourage them to try out exploratory learning strategies (Nielsen, 1994).

Insights 2 and 7 support Nielsen’s (1994) assertion that consistent user interfaces encourage exploratory learning strategies. The propensity of child novices to use the trial-and-error approach to learning a new software application relates to the principle of consistency in the sense that consistent system feedback and responses to user action allows the child novice to learn how to play in this way. If system feedback and responses are consistent, child novices will have more success in their exploratory approach to learning.

5.2.6 Reformulation of the Learnability Principle

The above discussion shows that the learnability principle for software design is generally aimed at products for adults, where emphasis is placed on improving work performance and productivity. Children represent an important user group, and it is important to understand what learnability means to them. As is evident from the discussion of the findings of this study above, the subprinciples of learnability can be applied differently for children and adults. The principles can therefore be reformulated as follows:

Predictability is more crucial in adult products than in those aimed at 9-to 13-year-olds. Adults prefer a predictable system, since they like to be sure of what happens next and what they are allowed to do next, while children are more willing to try out different things and just explore. Children are less concerned about the effects of their actions than adults.

Synthesisability has a different meaning for the two user groups since their differing levels of experience will influence the way they form mental models about the working of a system. When designing for children, designers should thus be aware that children may construct different mental models from what they (the adult designers) would expect.

A system that adheres to the principle of familiarity for adults may include elements with which children are not familiar. On the other hand, the fact that children are exposed to technology from early on, may mean that new input mechanisms that they have been exposed to through computer games may be unfamiliar to older people.

The consequences of generalisability and consistency on learnability may be different for each user group, but there is no indication from the derived insights that the two user groups understand the meanings of the two principles differently.

A major contribution of this research is a suggested extension to the learnability principle. Below, I present a new subprinciple, namely engageability, that I propose as an addition to the existing learnability subprinciples.

5.2.7 Engageability

Engageability is a proposed new subprinciple of learnability. The principle emerges from some of the insights which could not be related to the existing principles. I define engageability as:

> *the extent to which a software application can fully engage a user by providing a complete and satisfying user experience.*

Following the engageability principle enables users to be self-regulated, to define their own learning goals and to evaluate their own achievements. An engaging software application will naturally support users in knowing how to learn and be able to transfer knowledge. Engageability also promotes collaborative use supporting the possibility of users sharing the experience.

Forms of engageability can be found in a number of insights. Insight 9, for example, relates to children appreciating interactive demonstrations, as opposed to the more direct demonstrations that adults appreciate. To make an application engaging for a child, it should thus not expect them to passively watch a demonstration before they can start using the system. Adults, on the other hand may lose interest if they are unable to form a clear and holistic view of the system before they start to use it (Insight 6). Insight 10 is about children and adults engaging with the system and becoming more engaged and involved if they are using software that relates to them. Adults connect their learning of new software applications to life experiences and knowledge that may include work-related activities, family responsibilities, and even previous education. The relevance of a system for the child or adult user respectively, is thus an important aspect of engageability.

5.3 The learning process

Literature on the learning process alludes to differences in the way that adults and children learn. These differences were discussed in detail in Section 2.3.8.1. Insight 3 highlights the differences in the life experiences of adults and children as the source of observed cognitive differences between adults and children. It also relates to how adults learn new things through their past life experiences.

Insight 10 is related to von Glasersfeld’s (1989) discussion of the theory of social constructivism, which emphasises the importance of the learner being actively involved in the learning process. von Glasersfeld (1989) suggests that learners construct and interpret knowledge out of their personal experiences. Children are simply happy to accept what they are learning regardless of its purpose, but adults appreciate learning if it gives added value and meaning to their lives.

Literature on the characteristics of adult learners states that adult learners need to know why they should learn something before undertaking to learn it. This viewpoint supports the idea that adults are cautious in what they do when learning to use a new software application. Given the rationale for learning something, adults will often invest considerable energy in investigating the increased benefits to be gained from the learning experience and the consequences of not learning it. Insight 7 relates to this characteristic, when it addresses the concept of children trying out new things just to see what happens and not being intimidated by the possibility of something going wrong. Adults, on the other hand, are more cautious and tend to be more self-critical than children. Adults are rigid in what they expect of a user interface, whereas children like to explore.

According to the literature, children can learn through trial-and-error, which is the earliest stage of problem solving. Insight 2 relates to this literature, when it highlights the different learning techniques of children and adults. Adults rely on instructions and are more systematic in how they approach learning a new application, whilst children are more willing to use trial-and-error in learning to achieve an objective.

5.4 Learning strategies

The literature suggests that learning strategies are techniques and skills that an individual chooses to use in order to accomplish specific learning tasks. The insights also suggest that, through focus on metacognition, adult learners prefer to learn through self-assessment, self-correction and prior experiences. However, the insights suggest that children use a contingency approach to learning strategies, using them in problem solving tasks, but ignoring them completely or using them only sparingly when playing games.

5.5 Conclusion

This chapter draws parallels between the findings of the literature survey and the insights of the study. This process provides me, and others interested in this study, with a better understanding of the learnability principles, the learning process and learning strategies and how these relate to the use of software applications by both children and adults. It can be concluded that the application of learnability principles derived for products intended for adults may result in products that are not suited for children. Designing for children requires subtle re-interpretation of the principles of predictability, synthesisability and familiarity. Furthermore, an additional subprinciple, namely engageability, is proposed to incorporate aspects of learnability that are not covered by the existing subprinciples. Engagement is crucial for learnability. What makes a product engaging for children is different from what would make one engaging for adults. This chapter has thus provided an answer to the main question that this research endeavoured to answer. The learnability principle indeed has different meanings for children and adults.

Chapter 6 provides a conclusion to this study, a reflection on the research process and some recommendations for future studies.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This is the concluding chapter of this dissertation. It presents a summary of the research findings. The study focused on comparing the meaning of the learnability principle for children and adults. The general objective was to determine the differences in how adults and children learn a new software application. Specifically, the study sought to answer the following question:

Does learnability of software interfaces have a different meaning for children and adults?

In Chapter 5 I discussed the research findings and related them to the literature review in Chapter 2. Chapter 5 also discussed the reformulation of the learnability principle in order to better cater for the needs of users of different age groups. This study yielded useful guidelines for the design of software applications suitable for both children and adults.

The rest of this chapter is organized as follows: Section 6.2 discusses the contribution of the study. Abridged discussions on the limitations of the study is given in Section 6.3. Recommendations for future work follow in Section 6.4. The chapter closes with some concluding remarks in Section 6.5.

6.2 Contribution of the study

The data analysis section of this study provided answers to the research question and its subquestions. Summaries of these answers are given below. Conclusions were drawn from the findings and corresponding recommendations were made.

6.2.1 The Meaning of the Learnability Principle

The learnability principle is concerned with interactive system features which aid novice users to learn quickly and to make steady progress towards achieving mastery.

The subprinciples of the learnability principle, namely predictability, synthesisability, familiarity, generalisability, and consistency provide adequate guidance for the design of software applications that are intended for adults. However, the application of the same learnability subprinciples to the design of software intended for children yields mixed results. The findings of this study suggest the reformulation of the learnability principle to include the subprinciple of engageability, as was discussed in subsection 5.2.6.

Below, I briefly summarise the answers to the subquestions that guided the study and then summarise the reformulation of the learnability principle.

Subquestion 1: *With which aspects of software interfaces do children and adults struggle?*

Adults struggle if they do not have clear instructions or the relevant frame of reference to help them forward in their interaction. They struggle to get past unexpected situations and will keep on trying what they think is right rather than moving on and trying a different approach.

If adults are confronted with an input mechanism that they have not used before, they struggle more to adapt to it than children do.

Adults struggle with mouse and keyboard co-ordination during application navigation**.** Software designers should therefore incorporate customisation to make it easy for their application users to use either one or other input device, in order to reduce co-ordination probems encountered when forced to use both input devices.

Subquestion 2: *With what aspects of software interfaces do adults and children respectively have no problems and find engaging to do?*

Children adapt to interface problems very easily as they just try different things until something works. They are willing to make mistakes in order to progress faster. Children find it easy and engaging to explore the user interface, especially identifying clickable areas or exploring the sound effects produced by various screen elements produce.

Children enjoy creating their own pictures with the help of simulated environments. Children find game software easy and engaging to learn and use, whilst adults can adapt to learning software applications which are useful for their work and home environments and find them engaging.

Adults are better at following on-screen instructions and using the demonstrations and tutorials before they enter an application. Adults ask for help more easily than children do – either from an expert or by consulting the application's instructions.

Animation and sound effects are positive design elements for adults. These design elements often create a good first impression that encourages users to want to do more. Adult users find it easy and useful to learn how to do formatting, custom animation, slide show, slide transitions, and Clip Art.

It can be concluded that users appreciate an application that allows them to explore various options in the way that the application can be used. Application designers should thus include such positive design elements in their designs, building robustness and flexibility into the application.

Subquestion 3: *What differences are there between children and adults in their emotional reaction to interface elements?*

Adults are more vocal during the experiments, especially when they became frustrated. They tend to be more easily frustrated than children, for example, they are disturbed by an incorrect message, while children just continue without taking much notice.

It can be concluded here that children and adults have different ideas about what is boring and what is exciting. Designers should avoid using their own definitions of such concepts to guide their design decisions. They should rather tap ideas from their user community.

Subquestion 4: *What information does eye-tracking provide regarding differences in the behaviour of adults and children, when learning to use an unfamiliar computer game?*

The results of this study indicate that there is a notable difference in the visual focus of adults and children when learning to use an unfamiliar computer game. Adults tend to read instructions during initial stages of the game, while children start to explore the game without consulting instructions. Children focus on the game elements and use a trial-and-error approach instead of reading on-screen instructions. They tend not to rely on tutorial material to learn how to play the game. Adults, on the other hand, are more willing to interrupt game play in order to consult instructions.

What this tells us about the learnability principle is that, when evaluating the learnability of an interactive game designed for children aged between 10 and 12 years, the presence of tutorials and text-based on-screen instructions should not be valued highly. This also has implications for console games that usually come with written instructions. Do children ever read these instructions before playing the game?

At this point I can now provide the answer to the main question, namely:

Does learnability of software interfaces have a different meaning for children and adults?

Learnability of software interfaces has a different meaning for children and adults. Relating these results to the differences in general between how adults and children learn, the following was concluded:

a) Whereas adults usually rely on themselves in the learning process, they depend on the support of instructions more than children do.
b) Adults are noticeably more self-directed than children in their learning.
c) Adults do not derive any significant advantage from their broader life experiences when they are learning to play a new game. Children, on the other hand, display more initiative when faced with novel situations.

These findings on the differences between the general learning styles of children and adults could serve as bases for recommendations to application designers on ways in which they can better target their intended end users.

6.2.2 The Reformulated Learnability Principle

The differences that were identified between how children and adults understood the meanings of predictability and synthesisability, led to the reformulation of the learnability principle. The consequence of such reformulation is that the learnability principle should be applied differently depending on whether or not the product is designed for adults or for children (see Section 5.2.6).

A new subprinciple, engageability, was proposed as a new learnability subprinciple. It refers to the extent to which a software application can fully engage a user by providing a complete and satisfying user experience. The principle emerged from some of the insights which could not be related to the existing subprinciples. However, before engageability can become a mainstream learnability subprinciple, it will have to be subjected to the scrutiny of the HCI research community. What this research has achieved is to set this process in motion.

6.2.3 Recommendations for Design

The recommendations given below are summaries of the implications for design given in Section 4.3.2.

Recommendation 1

Designers of software should take into account aspects of the principle of predictability when they produce software intended for children. The software should be designed in such a way that, although instructions are available, children or adults can use the software without instructional guidance. Designers of software intended for children should not rely on written instructions to inform children on how to use the software. As noted in the experiments, children learn through trial-and-error and are not scared to experiment to find out what would happen. The products must be robust and fault-tolerant so as to cope with children who learn through trial-and-error and are adventurous in experimenting with the software.

User interface designers should be particularly aware of elements of predictability in user interfaces of applications designed for adults. For example, software designers should provide operator instructions for software designed for adults.

Recommendation 2

The instructions for the software must be clearly evident for users. Designers should make instructions clearly detectable and well-positioned on the user interface so that application users would be more likely read them. The instructions must not be lengthy or extensive and should also make use of graphic elements to make them more appealing to their users. Users are interested in the graphical elements, game play and interaction, not in reading lengthy instructions; this is particularly important to children.

Users should be guided through initial use of the software. If there is a chance that adults will use the product, tutorials that give product overviews should be provided. However, since children tend not to read instructional guides, software application designers should not assume that all users will benefit from instructional guides. Designers should rather aim to accommodate the requirements of both types of users.

Recommendation 3

Designers should design software which encourages all age groups to explore and discover other ways of doing things. Designers must take into account the use and coordination of mouse and keyboard by both children and adult users as they design software. Understanding the connection between moving a mouse and movement on a computer screen can sometimes take time to develop, as can the concept of making choices. Software designed for adults should help them master not only the concepts underlying task activities, but also the motor control necessary if the mouse is to be used for other things, rather than just clicking.

Recommendation 4

Independent learning is an important aspect in the learning of a new software application and with this in mind, designers must include elements that facilitate independent learning. For example, software that is designed for adults should provide additional, more detailed, instructions such as 'help/instructions' on how the application is used.

Recommendation 5

Applications designed for children should show greater tolerance for incorrect operation than applications designed for adults. Designers of software applications intended for children should adopt robustness and fault-tolerance as some of their design goals.

Recommendation 6

As part of the learning process, application designers should include elements of user interface design that reinforce positive emotions in the application user. For example, if users are given a choice to customise interfaces, this could help with the acceptance of the application. If a game allows them options in selecting elements with which to interact, the users might accept the game better.

Recommendation 7

Designers of software applications intended for adults should make the value of learning a new application apparent. Adult learning is value-driven. Adult learners need to know why they should learn something before they undertake to learn it. Given the rationale for learning something, they will often invest considerable energy in investigating the increased benefits to be gained from the learning experience and the consequences of not learning it. Adults want to learn concepts that are related to a setting familiar to them and that they can use afterwards.

Recommendation 8

Designers should take into account the different needs of user groups and make use of such specifications in the designing of software. Application designers should design software for a specific group based on the individual group's needs and goals. Different user groups have their own skills and abilities, therefore design principles for one group cannot be scaled down or improved to suit the other group.

6.3 Limitations of the study

A limitation of the study was that the experiments were all conducted in a usability laboratory that isolated participants in a controlled laboratory environment, where they could interact only with the facilitator and complete tasks with only the tools provided. Working under such a controlled environment introduces bias into the results of the study. Perhaps a combination of both controlled and natural settings would produce less biased results. Users' behaviour can be influenced by the fact that they are being observed and some of the behaviour observed during the experiment may have been different in a natural setting (Chimbo and Gelderblom, 2008).

External validity, or the generalisability of the study, is limited by the fact that only 28 participants took part in the complete study. Although the children represented different cultural groups and home languages, they were all from two schools situated in relatively privileged areas. The adult participants were from the same work place, although from different colleges and departments. They did, however, represent a range of skill levels (from a full professor to a security guard) and cultural groups. In future, it would be helpful to use a larger number of participants representing a wider range of schools and places of work.

The limitations of this study also bring forth some fruitful and interesting possible avenues for future research that might be needed in relation to the theme of the study.

6.4 Future Work

Grounding the basis of the learnability principles in the work of one source, namely Dix et al. (2004), can be regarded as a limitation of this study. The lack of sources in the literature that deal specifically with the learnability principle suggests a gap in the body of knowledge. This study was an attempt at filling that gap, but more work needs to be done to improve the granularity in the description of the subprinciples. Specifically, better distinction between some of the principles, for example, generalisability and consistency, could be achieved through further research. More work also needs to be done to confirm the value of the 'engageability' principle proposed.

The literature suggests that 'play' is an important way in which children learn. The issue of play did not surface during my data analysis. In order to investigate the role of play in learning to use a software application, the choice of software applications to use in the study would be different from what was used here. The two games used in this study were designed for children and it can therefore be problematic to make deductions about adult game play from these experiments. In future one can investigate the role of play by also letting adults learn to use games designed for adults.

6.5 Conclusion

This chapter presented conclusions and made recommendations based on the findings of the study. A potential implication of identifying the above-mentioned learnability categories is that design guidelines for improving learnability which isolate these specific categories can be developed.

The study highlighted the need for software designers to correct or improve their products in a way that best supports the specific user group. The end result ultimately aided in the reformulation of the learnability principle in a way that distinguishes between the needs of adults and children. The findings served as foundations of evaluation criteria for software for children. This study also highlighted the need to increase the granularity of the learnability principles in order to reduce mutual semantic overlap between the concepts. The way in which the learnability principles are currently defined makes it difficult to clearly distinguish one from the other.

In conclusion, the objective of the overarching study, which was to compare the meaning of learnability for children and adults, was achieved. The comparison yielded some interesting results for both HCI practitioners and software designers. It is hoped that the findings of this study will help to advance HCI practice and to improve the quality of software targeted at different user age groups.

REFERENCES

Alessi, S. M. & Trollip, S. R. 2001. *Multimedia for learning: Methods and Development.* USA: A Pearson Education Company.

Anderson, A. 1992. *Learning Strategies in Physical Education: Self-Talk, Imagery, and Goal-Setting.* JOPERD - The Journal of Physical Education, Recreation and Dance, Vol. 68.

Aspinall, D. 2007. *Principles and Guidelines Interface Design Rules: Informatics*. UK: University of Edinburgh.

Aula, A., Majaranta, P. & Raiha, K. J. 2005. *Eye-tracking reveals the personal styles for search result evaluation.* In: INTERACT 2005, M. Costabile and F. Paternò, (eds.).

Baine, D. 1986. *Memory and Instruction*. Englewood Cliffs, NJ: Educational Technology Publications.

Baumgarten, M. 2003. *Kids and the Internet: A Developmental Summary*. ACM Computers in Entertainment, 1, Article 2.

Beaver, M., Brewster, J., Jones, P., Keene, A., Neaum, S. & Tallack, J. 2001. *Babies and young children: diploma in child care and education*. Nelson Thornes.

Becker, B. & Becker, P. 2008. *Developing Quality Care for Young Children: How to Turn Early Care Settings into Magical Places.* Corwin Press.

Bednarik, R. & Tukiainen, M. 2006. *An eye-tracking methodology for characterizing program comprehension processes.* In ETRA, San Diego, California.

Bojko, A. & Stephenson, A. 2005. *It's all in the eye of the user: How eye tracking can help answer usability questions.* User Experience, Vol. 4, No. 1.

Bonwell, C. C. & Eison, J. A. 1991. *Active learning: Creating excitement in the classroom.* Washington, DC: ASHE-ERIC Higher Education Report No. 1.

Bowling, A. 2002. *Research Methods in Health: Investigating Health and Health Services.* 2nd ed. New York, NY: Open University Press.

Brookfield, S. 1995. *Adult Learning: An Overview, International Encyclopedia of Education.* Oxford: Pergamon Press.

Burns, S. 1995. *'Rapid changes require enhancement of adult learning'*, pp. 16-17.

Burrell, G. & Morgan, G. 1979. *Sociological paradigms and organizational analysis.* London: Heinemann., p. 24.

Cave, J., LaMaster, C. & White, S. 2006. *Adult characteristics.* Available from:
< http://ed.fnal.gov/lincon/staff_adult.shtml> [Accessed: May 15 2009].

Charles, C. M. 1995. *Introduction to educational research.* 2nd ed. San Diego: Longman.

Chen, C. S. 2002. *Self-regulated Learning Strategies and Achievement in an Introduction to Information Systems Course: Information Technology, Learning, and Performance.* Journal, Vol. 20, No.1.

Chiasson, S. & Gutwin, C. 2005. *Design Principles for Children's Software, Technical Report.* HCI-TR-05-02, Computer Science Department, University of Saskatchewan.

Chimbo, B. 2006. *Usability evaluation of Storybook Weaver Deluxe 2004 Educational Software among culturally diverse South African children between the ages of 6 to 8 years.* (A research report in part fulfillment of the Honours degree in Information Systems). University of South Africa.

Chimbo, B. and Gelderblom, H. 2008. *The suitability of American storytelling software for South African Diversity*. Proceedings of the IADIS Multi Conference on Computer Science and Information Systems (MCCSIS) 2008: Amsterdam.

Conti, G. & Fellenz, R. 1991. *Assessing adult learning strategies.* Proceedings of the 32nd Annual Adult Education Research Conference. University of Oklahoma, Norman.

Cotton, J. 1995. *The theory of learning: An introduction.* London: Kogan Page Limited.

Creswell, J. W. 2009. *Research Design - Qualitative & Quantitative Approaches.* Thousand Oaks: Sage Publications, p. 121.

Crotty, M. 1998. *The Foundations of Social Research: Meaning and Perspective in the Research Process.* London: SAGE Publications.

Cunningham, D. J. 1991. *Assessing constructions and constructing assessments: A dialogue.* Educational Technology, (31) 5, pp. 13-17.

De Villiers, M. R. 2005. *e-Learning artefacts: are they based on learning theory?* Alternation 12.1b: pp. 345-371.

De Villiers, MR (Ruth). (2007) *Interpretive research models for Informatics: action research, grounded theory, and the family of design- and development research*. Alternation 12.2 (2005): pp. 10-52.

De Villiers, M.R. 2009. *Applying controlled usability-testing technology to investigate learning behaviours of users interacting with e-learning tutorials.* In T. Bastiaens et al. (Eds.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2009. Chesapeake, VA: AACE. Vancouver, Canada, pp. 2512-2521.

Dix, A., Finlay, J., Abowd, G. & Beal, R. 2004. *Human-Computer Interaction*. Pearson Education.

Driscoll, M. 2000. *Psychology of learning for instruction*. 2nd ed. Needham Heights, MA: Allyn and Bacon.

Duffy, T. M. & Jonassen, D. H. 1991. *Constructivism: New implications for instructional technology*. (30) 10, pp. 7-12.

Dumas, J. S. & Redish, J. C. 1993. *A practical guide to usability testing.* Norwood, NJ: Ablex. Publishing Company.

Durrheim, K. 1999. Research Design. In Terre blanche, M. and Durrheim, K. (Eds) *Research in Practice: Applied Methods for the Social Sciences.* Cape Town: UCT Press.

Ekwensi, F., Moranski, J. & Townsend-Slet, M. 2006. *E-Learning Concepts and Techniques.* Bloomsburg University of Pennsylvania's Department of Instructional Technology. 5.1 Instructional Strategies for Online Learning. Available from: <http://iit.bloomu.edu/Spring2006_eBook_files/ebook_spring2006.pdf>[Accessed: November 8, 2009].

Ellis, L. E., Asamen, J. K. & Berry, G.L. 2008. *The Sage Handbook of Child Development, Multiculturalism, and Media.* United Kingdom: Saffron Walden, Essex.

Erickson, F. 1982. *Audiovisual records as a primary data source.* Sociological Methods and Research, 11(2), pp. 213-232.

Erickson, F. 1992. *Ethnographic microanalysis of interaction.* In M. D. LeCompte, W. L. Milroy and J. Preissle (Eds.), *The handbook of qualitative research in education*. New York: Academic Press, pp. 201-225.

Ericsson, K. A. & Simon, H. A. 1998. *How to study thinking in everyday life: Contrasting think-aloud protocols with descriptions and explanations of thinking. Mind, Culture, & Activity*. 5(3), pp. 178-186.

Ference, P. R. & Vockell, E. L. 1994. *'Adult learning characteristics and effective software instruction'*. Educational Technology, Vol. 34, pp. 25.

Fetterman, D. M. 1998. *Ethnography: Step by step*. 2nd ed. Thousand Oaks, CA: Sage.

Fishel, C. 2001. *Designing for Children*. Rockport Publishers, Inc.

Fisher, R. 2005. *Teaching children to think*. UK: Nelson Thornes.

Finkbeiner, C. 1998. *The promotion of explicit and implicit learning strategies in English instruction: a necessary aim*. <lbdoc.sub.gwdg.de> [Accessed: 10 December 2009].

Fritscher, R. 2009. *Cognitive Theory*. Available from:
< http://phobias.about.com/bio.htm> [Accessed: 10 June 2009].

Galliers, R. D. 1991. *Choosing Appropriate Systems Approaches: A Revised Taxonomy, Information Systems Research:* Amsterdam, North Holland.

Gelderblom, J. H. 2008. *Designing technology for young children: Guidelines grounded in a literature investigation on child development and children's technology.* PhD Thesis, University of South Africa.

Gibbons, M. 2002. *The Self-Directed Learning Handbook.* Available from: <http://www.selfdirectedlearning.com/SDLProgram.html> [Accessed: November 19 2009].

Goffree, F. & Stroomberg, H. (eds) 1989. *Creating adult learning; Theoretical and practical communications on educational design for adults.* Spruyt, Van Mantgem and De Does Bv/Leiden.

Golafshani, N. 2003. *Understanding Reliability and Validity in Qualitative Research: The Qualitative Report.* Vol. 8 Number 4, p. 603.

Goodlad, S. & Hirst, B. 1989. Peer *Tutoring. A Guide to Learning by Teaching*. New York: Nichols Publishing.

Goswami, U. 2002. *Blackwell handbook of childhood cognitive development*. Volume 11 of Blackwell handbooks of developmental psychology, Wiley-Blackwell.

Grammenos, D. & Stephanidis, C. 2002. *Interaction Design of a Collaborative Application for children.* In Bekker, M., Markopoulos, P. and Kerstin-Tsikalkina, M. (Eds.) Interaction Design and Children. Eindhoven, The Netherlands: Shaker Publishing.

Gravett, S. 2001. *Adult learning: Designing and implementing learning events: A dialogic approach.* Hatfield, Pretoria, South Africa: Van Schaik Publishers.

Gredler, M. E. 1997. *Learning and instruction: Theory into practice*. 3th ed. Upper Saddle River, NJ: Pearson Education.

Greig, A. & Taylor, J. 1999. *Doing research with children.* London: Sage.

Grimshaw, A. D. 1982. *Sound-image data records for research on social interaction: Some questions and answers. Sociological Methods and Research.* 11(2), pp. 121-144.

Grossman, T., Fitzmaurice, G. & Attar, R. 2009. *A Survey of Software Learnability: Metrics, Methodology and Guidelines.* Autodesk Research. Canada, M5A 1J7.

Grudin, J. 1989. *The case against user interface consistency.* Commun. ACM, 32(10), pp. 1164-1173.

Hanna, L., Risden, K. & Alexander, K. J. 1997. *Guidelines for Usability Testing with Children. Interactions,* pp. 9-14.

Herod, L. 2002. *Adult learning: From theory to practice.* Available from: <http://www.nald.ca/adultlearningcourse/module2/module2.htm> [Accessed: 30 November 2009].

Hinze-Hoare, V. 2007. *Review and Analysis of Human Computer Interaction (HCI) Principles*. Southampton University.

Holleran, P. A. 1991. *A methodological note on pitfalls in usability testing: Behaviour and Information Technology*. Vol. 10 No. 5, pp. 345-357.

Holmes, A. 2003. *Smart Things to Know About Lifelong learning.* Capstone Publishing Limited (a Wiley company).

Houle, C. 1980. *Continuing Learning in the Professions.* San Francisco: Jossey-Bass.

Howe, K.R. 1988. *Against the Quantitative-Qualitative Incompatibility Thesis or Dogmas Die Hard*: Educational Researcher, Vol. 17, No. 8, pp. 10-16.

Höysniemi, J., Hämäläinen, P. & Turkki, L. 2003. *Using peer tutoring in evaluating the usability of a physically interactive computer game with children: Interacting with Computers* v15, pp. 203-225.

Illeris, K. 2006. *How l learn: learning and non-learning in school and beyond*. Roskilde University Press.

Jacob, R. & Karn, K. 2003. Eye *tracking in Human-Computer Interaction and usability research.* In: J. Hyona, R. Radach, and H. Deubel, (eds.): *The mind's eye: Cognitive and applied aspects of eye movement research.* Elsevier Science.

Jarvis, P. 2006. *Towards a comprehensive theory of human learning*. 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN.

Jones, D. 2009. *Learning theories and e-learning*. Available from: <http://davidtjones.wordpress.com/2009/10/04/learning-theories-and-e-learning> [Accessed: 30 June 2010], p. 2.

Joppe, M. 2000. *The Research Process*: Available from: <http://www.ryerson.ca/~mjoppe/rp.htm> [Accessed: 16 December 2009].

Jorgensen, D. L. 1989. *Participant Observation: A Methodology for Human Studies,* Newbury Park, CA: Sage Publications.

Kato, T. 1986. *What "question-asking protocols" can say about the user interface.* International Journal of Man-Machine Studies, Volume 25, Issue 6, pp. 659-673.

Knowles, M. 1998. *The adult learner: The definitive classic in adult education and human resource development*. Boston: Gulf Publishing Company.

Kristoffersen, S. 2008. *Learnability and Robustness of user interfaces: Towards a Formal Analysis of Usability Design Principles.* ICSFT (SE/MUSE/GSDCA), pp. 261-268.

Lawther, J. D.1977. *The learning and performance of physical skills*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Leberman, S. Mcdonald, L. & Doyle, S. 2006. *The transfer of learning: Participants' perspectives of adult education and training.* England: Gower publishing limited, p. 131.

Lee, S.H. 1999. *Usability Testing for Developing Effective Interactive Multimedia Software: Concepts, Dimensions, and Procedures.* Korea: Educational Technology and Society 2(2).

Leedy, P. D. & Ormrod, J. E. 2010. *Practical research: Planning and Design*. New Jersey: Pearson Education.

Likart, D. P. & Hohmann, M. 1995. *Educating Young Children: Active Learning Practices for Preschool and Child Care Programs.* High/Scope Foundation.Ypsilanti, Michigan.

Linstein, C. E. & Mayer, R. E. 1986. *The teaching of learning strategies*. 3rd ed. In M. C. Wittrock (Ed.), Handbook of research on teaching, New York: Macmillan, pp. 315-327.

Long, H. B. 1990. *Advances in research and practice in self-directed learning*. USA: McGill, Oklahoma Research Center.

Malone, T. W. 1982. *Guideline for Designing*. Educational Programs. Childhood Education, 59, pp. 241-247.

Marsick, V. J. & Watkins, K. 1986. *Approaches to studying, learning in the workplace.* In V. J. Marsick (Ed.), Learning in the Workplace. London: Croom Helm, pp. 171-198.

McGill, I. & Beaty, L. 1995. *Action Learning*: a *guide for professional, management and educational development*. 2nd ed. London: Kogan Page.

Merriam, S. B. 1998. *Qualitative Research and Case Study Applications in Education*. San Francisco, CA: Jossey-Bass.

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. 2007. *Learning in adulthood: A comprehensive guide* (3rd ed.). San Francisco: Jossey-Bass.

Miles, M. B. & Huberman, A. M. 1994. *Qualitative Data Analysis.* 2nd ed. Thousand Oaks, CA: Sage Publications, p. 56.

Mouton, J. 2001. How *to succeed in your Master's and Doctoral Studies: A South Africa Guide and Resource Book.* Pretoria: Van Schaik.

Neuman, W. L. 2003. *Social Research Methods-Qualitative and Quantitative Approaches.* 5th ed. USA: Pearson Education.

Nielsen, J. 1993. *Usability Engineering*. San Francisco: Morgan Kaufmann.

Nielsen, J. 1994. *Usability Engineering*. Academic Press.

Nisbert, J. D. & Shucksmith, J. 1986. *Learning Strategies*. Routledge and Kegan Paul plc.

Olivier, M. S. 2004. *Information Technology Research: a practical guide for Computer Science and Informatics*. Pretoria, South Africa: Van Schaik Publishers.

Oxford, R. L. 1990. *Language Learning Strategies: What Every Teacher should now*. Boston: Heinwee and Heinle. Available from: <http: //www.k12.nf.ca/fatima/define.htm> [Accessed: 27 April 2009].

Patton, M. Q. 2001. *Qualitative Research and Evaluation Methods* (2nd Ed). Thousand oaks, CA: Sage Publications.

Penzo, M. 2005. *Introduction to Eyetracking: Seeing Through Your Users' Eyes.* Available from: <http://www.uxmatters.com/mt/archives/2005/12/> [Accessed: 18 June 2010].

Piley, I. 2010. *What Are Perceptual Motor Skills?: eHow Contributor*. Available from: <http://www.ehow.com/facts_5900878_perceptual-motor-skills_.html> [Accessed: 24 September 2009].

Polit, D. F. & Hungler B. P. 1999. *Nursing Research. Principles and Methods*. 6th ed. Philadelphia, Lippincott.

Polit, D. F., Beck, C. T. 2004. *Nursing Research: Principles and methods* 7th ed. Philadelphia: Lippincott Williams & Wilkins, p. 730.

Prawat, R. S. & Floden, R.W. 1994. *Philosophical perspectives on constructivist views of learning.* Educational Psychology, 29, pp. 37-48.

Preece, J., Rogers, Y. & Sharp, H. 1994. *Human Computer Interaction*. Addison Wesley.

Preece, J., Rogers, Y. & Sharp, H. 2007. *Interaction design: Beyond human-computer interaction.* 2nd ed. John Wiley and Sons, Inc.

Pretorius, M., Calitz, A. & Van Greunen, D. 2005. *The added value of eye tracking in the usability evaluation of a network management tool.* In SAICSIT, White River, South Africa: ACM Press, pp. 1-10.

Pretorius, M., Gelderblom, H. J. & Chimbo, B. 2010. *Using Eye-Tracking to compare how adults and children learn to use an unfamiliar computer game*. In SAICSIT, Bela Bela, South Africa: ACM Press.

Puttergill, C. 2000. *Strategies of Discovery*. In Collins, K. J., Plooy, G.M.D., Grobbelaar, M.M., Puttergill, C. H., Terreblanche, M.,J., Eeden, R. V., Rensburg, G. H.V. and Wigston, D.J. (Eds) Research in the Social Sciences: Only Study Guide for RSC201-H Pretoria: Unisa Press.

Quam, K. F. 1998. *Fundamentals of Teaching and Learning*. Kroshka Books.

Ramey, C. T. & Ramey, S. L. 2004. *How children learn and how parents can help: Center for Development and Learning*. Covington, LA 70433.

Roger, J. 2007. *Adult Learning*. London: Open University Press.

Roschelle, J., Pea, R., Hoadley, C., Gordin, D. & Means, B. 2001. *Changing How and What Children Learn in School with Computer-Based Technologies. The Future of Childre.,* 10(2). Los Altos, CA: Packard Foundation. pp. 76-101.

Rubin, A. & Babbie, E. 2001. *Research methods for social work.* 4th ed. Belmont, CA: Wadsworth/Thomson Learning.

Rubin, J. & Chisnell, D. 2008. *Handbook of usability testing: how to plan, design, and conduct effective tests.* Wiley Publishing.

Rudmann, D., McConkie, G. & Zheng, X. 2003. *Eyetracking in cognitive state detection for HCI.* In ICMI'03, Vancouver, British Columbia, Canada.

Rugg, G. 2006. *Report*: Available from:
<http://www.google.co.za/search=Rugg+Think+Aloud> [Accessed: 10 February 2010].

Rushton, S. P., Eitelgeorge, J. & Zickafoose, R. 2003. *Connecting Brian Cambourne's Conditions of Learning Theory to Brain/Mind Principles*: *Implications for Early Childhood Educators.* Early Childhood Education Journal, Vol. 31, No. 1.

Salthouse, T. A. 1991. *Theoretical perspectives on cognitive aging*. Hillsdale, NJ: Lawrence Erlbaun Associates, p. 176.

Santos, P. J. & Badre, A. N. 1995. *Discount learnability evaluation.* GVU Technical Report GIT-GVU-95-30. Georgia Institute of Technology.

Savoy, A., Proctor, R. W. & Salvendy, G. 2009. *Information retention from PowerPointTM lecturers: Computers and Education*. Vol. 52, No 4, pp. 858-867.

Saywitz, K. J., Geiselman, R., & Bornstein, G. 1992. *Effects of cognitive interviewing and practice on children's recall performance.* Journal of Applied Psychology.

Schumaker, J. B. & Deshler, D. D. 1992. *Validation of learning strategy interventions for students with LD: Results of a programmatic research effort*. In Y. L. Wong (Ed.), Contemporary intervention research in learning disabilities: An international perspective. New York: Springer-Verlag.

Schmuck, R. 1997. *Practical action research for change.* Arlington Heights, IL: IRI/Skylight Training and Publishing.

Schneiderman, B. 1998. *Designing the User Interface*. 3rd ed. Addison Wesley, Longman Inc.

Senapathi, M. 2005. *A Framework for the Evaluation of CASE Tool: Learnability in Educational Environments.* Journal of Information Technology Education, Volume 4.

Sharon, T. & Woolley, J. D. 2004. *Do monsters dream? Young children's understanding of the fantasy/reality distinction*. British Journal of Developmental Psychology, 22, pp. 293–310.

Shneiderman, B. 1997. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Addison-Wesley Longman Publishing Co., Inc.

Siedel, J. 1998. *Qualitative Data Analyisis. The Ethnograph v5 Manual*. Appendix E. Available from: <http://www.qualisresearch.com/> [Accessed: 9 December 2009].

Siemens, G. 2006. '*Connectivism: Learning theory or pasttime for the self-amused.'* Available from: <http://davidtjones.wordpress.com/2009/10/04/learning-theories-and-e-learning> [Accessed: 18 June 2010].

Skinner, B. F. 1938. *The Behaviour of Organisms*. New York: Appleton-Century Crofts.

Skinner, B. F. 1957. *Verbal Behaviour*. London: Methueu.

Skinner, B. F. 1974. *About Behaviourism*. New York: Knop.

Smith, M. K. 2001. *'David A. Kolb on experiential learning'*: *the encyclopedia of informal education*. Available from: < http://www.infed.org/b-explrn.htm> [Accessed: 15 July 2009].

Solter, A. 1992. *Principles of Learning*. Available from: <http://www.awareparenting.com/learning.htm> [Accessed: 2 August 2009].

Strauss, A. L. & Corbin, J. 1998. *Basics of Qualitative research techniques and Procedures for Developing Grounded Theory*. USA: Sage.

Terre Blanche, M. & Kelly, K. 1999. *Interpretive Methods*. In Terre Blanche, M. and Durrheim, K (Eds) *Research in practice*: *Applied methods for the social sciences*. Cape Town, UCT Press.

Thorne, S. 2000. *Data analysis in qualitative research: Evidence Based Nursing*. 3, pp. 68-70.

Thorndike, E. L. (1931) *Human learning*. New York: Appleton-Century-Crofts.

Thornton, S. 2002. *Growing Minds,* London: Harvard University Press.

Trochim, W. M. K. 2006. *Research Methods knowledge;* Available from <http://www.socialresearchmethods.net/kb/sampling.php> [Accessed: 30 March 2010].

Vagenshtein, Y. F. 2008. *How Illiterate People Learn: Case Study of Ethiopian Adults in Israel*. Journal of Literacy and Technology 26, Volume 9, Number 3.

van Joolingen, W. 1999. *Cognitive tools for discovery learning*. International Journal of Artificial Intelligence in Education, 10, pp. 385-397.

Venezky, R. & Osin, L. 1991. *The Intelligent Design of Computer-Assisted Instruction*. New York: Longman.

von Glasersfeld, E. 1989. *Constructivism in education*. In T. Husen and N. Postlewaite (Eds.), International Encyclopedia of Education [Suppl.]. Oxford, England: Pergamon Press, pp. 162-163.

Vygotsky, L. 1978. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, Mass, Harvard University Press.

Webster, K., Zachariah, M., McFaury, J. & McMullin, L. 2001. *Do adults and children learn differently?.* Available from: <http://fcis.oise.utoronto.ca/~daniel_schugurensky/faqs/qa9.html> [Accessed: 20 May 2009].

Welman, J. C. & Kruger, S. J. 2001. *Research Methodology for the Business and Administrative Sciences.* Cape Town: Oxford University Press.

Wertsch, J.V. 1997. '*Vygotsky and the formation of the mind'*. Cambridge.

Woolley, J. D. 1997. *Thinking about Fantasy: Are Children Fundamentally Different Thinkers and Believers from Adults?* Child Development, Vol. 68, No. 6, pp. 991-1011.

Xiangui, Z. 2005. *Learning Theories and Second Language Learning*. Celea Journal 63, Vol. 28, no 5. pp 120-127.

Zimmerman, B. J. & Martinez-Pons, M. 1989. *Development of a structured interview for assessing Self-regulated Learning Strategies and Achievement in an Introduction to IS Course 23 student use of self-regulated learning strategies.* American Educational Research Journal, 23(4), pp. 614-628.

APPENDICES

Appendix A: The schedule of the usability laboratory sessions

DATES	Software application	Participants (expert)	Participants (novice)	TIMES
30/11/2009	TA	CE_1	CEN_2	12:30
04/12/2009	TA	CE_1	CN_3	12:00
04/12/2009	TA	CE_1	AEN_3	13:00
30/10/2009	TA	CEN_2	AN_2	11:00
30/11/2009	TA	AE_1	AN_4	14:00
Pilot Study	TA	CE	CN	14:00
Pilot Study	TA	CE	AN	15:00
11/11/2009	TA	Teaching self	CN_5	11:00
30/11/2009	TA	Teaching self	CN_4	13:00
30/11/2009	TA	Teaching self	CN_{10}	14:00
04/12/2009	TA	Teaching self	CEN_7	14:30
02/12/2009	TA	Teaching self	AN_{10}	1400
04/12/2009	TA	Teaching self	CEN_8	12:00
04/12/2009	TA	Teaching self	AN_{11}	13:00
04/12/2009	TA	Teaching self	AN_{12}	11:00
02/12/2009	SBW	CE_5	CN_6	12:30
04/12/2009	SBW	CEN_2	CN_9	14:00
04/12/2009	SBW	CEN_2	CN_3	15:00

01/12/2009	SBW	CEN_7	CEN_8	13:30
09/04/2010	SBW	AE_1	AN_{14}	12:00
09/04/2010	SBW	Teaching self	AN_{13}	11:00
01/05/2010	SBW	Teaching self	AN_{14}	13:00
10/05/2010	SBW	Teaching self	CN_{11}	18:00
10/05/2010	SBW	Teaching self	CN_{12}	19:00
02/12/2009	MSO	CEN_8	AN_6	12:00
30/11/2009	MSO	AEN_5	AN_7	09:30
18/11/2009	MSO	AE_1	CN_{10}	14:00
30/11/2009	MSO	CE_1	CN_7	16:00
01/05/2010	PPT	Teaching self	CN_{11}	16:00
02/05/2010	PPT	Teaching self	CN_{12}	17:00
03/12/2009	PPT	CE_1	AN_8	12:00
03/12/2009	PPT	AEN_3	AN_9	14:00

Key:

TA: Timez Attack

SBW: StoryBook Weaver

MSO: Microsoft Outlook

PPT: PowerPoint Presentation

Appendix B: Interviews and Questionnaires

1. Demographic Information Questionnaire

*(Please note, your information will **not** be sold or given to outside entities. It is for internal use only.)*

Q1. Gender:

Female	Male

Q2. Age Group in years:

10-13	35-40	Over 40

Q3. Education History:

Junior School	Middle School	Higher Education

Q4. Employment History:

Employed	Unemployed	Not Applicable

Q5. General level of Computer experience:

Low	Moderately low	Moderately high	High

Q6. Previous experience with these software applications:

	Yes	No
Times Attack		
Story Book Weaver		
Microsoft Outlook		
Microsoft Power Point		

2. Informal semi-structured interview questions

Informal, semi structured interviews were conducted with all participants.

A The questions below will be used as a guide during the interview and were adapted based on specific feedback and new information that transpired during the experiments.

1. How did you find participating in this experiment?
   To probe further:
   - Did you feel uncomfortable being watched/ recorded?
   - Did you feel shy/ confident to work with your partner?
2. Was it difficult or easy to learn to use the software?
3. Did you find it easy to teach your partner?
4. Which parts of the software did you do the following?
   Enjoy

   Not Enjoy

   Find difficult

   Easy
5. Were you able to learn and master all the required activities?
6. Was discovering new features easy?
7. This software is satisfying to use?

B Questions the observer will have in mind while observing the participants during experiments.

1. Is the software easy to use?

2. Are participants in control of the contents of the menus and toolbars?

3. Is navigating through the menus and toolbar easy to do?

4. Is the software flexible? Is finding the options that participants want in the menus and toolbars easy?

5. Is the software engaging? Do the contents of the menus and the toolbars match their needs.

6. Is it easy to make the software do exactly what participants want?

7. Is the "teacher" succeeding in teaching the "learner".

8. **Consistency**: Is the software/interface consistent?

9. **Predictability**: Does the software application behave predictably in similar situations?

10. **Familiarity**: Does the software application behave familiarly in similar situations?

11. **Generalisability:** Is the interactive design principle that provides support for users to extend knowledge of specific interaction within, and across applications, to new, but similar situations being met?

12. **Synthesizability:** Is it easy for users to assess the effect of past operations on the current state?

Appendix C: Ethical clearance form

UNIVERSITY OF SOUTH AFRICA
COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY

ETHICAL CLEARANCE APPLICATION FORM
Date: __2009/07/29________

PLEASE NOTE THAT THE FORM MUST BE COMPLETED IN TYPED SCRIPT. HANDWRITTEN APPLICATIONS WILL NOT BE CONSIDERED.

SECTION 1: PERSONAL DETAILS

1.1 Full Name and Surname of Applicant:	**Bester Chimbo**
1.2 Title (Ms/ Mr/ Mrs/ Dr/ Professor/etc.):	Mrs
1.3 Student Number (where applicable):	32950063
Staff Number (where applicable):	90067320
1.4 School:	School of Computing
1.5 College:	College of Science, Engineering and Technology
1.6 Campus:	Pretoria Main Campus
1.7 Existing Qualifications:	BEd Honours and BSc Honours
1.8 Proposed Qualification for Project: (In the case of research for degree purposes)	MSc
2. Contact Details	
Telephone Number	012 4296933
Cell. Number	0823338815
e-Mail address	chimbb@unisa.ac.za
Postal address (in the case of students and external applicants)	P.O. Box 1677 Pretoria, 0001

3. SUPERVISOR/ PROJECT LEADER DETAILS

1.2 NAME	1.3 TELEPHONE NO.	1.4 EMAIL	2.3.1 SCHOOL / INSTITUTION	1.4.1.1 QUALIFICATIONS
3.1 Dr Helene Gelderblom	012 429 6631	geldejh@unisa	UNISA	PhD (UNISA)
3.2 Prof Ruth De Villers	012 429 6559	dvillmr@unisa	UNISA	PhD (UP)

SECTION 2: PROJECT DESCRIPTION

Please do *not* provide your full research proposal here: what is required is a short project description of not more than two pages that gives, under the following headings, a brief overview spelling out the background to the study, the key questions to be addressed, the participants (or subjects) and research site, including a full description of the sample, and the research approach/ methods

2.1 Project title	COMPARING THE MEANING OF THE 'LEARNABILITY' PRINCIPLE FOR CHILDREN AND ADULTS
2.2 Location of the study (where will the study be conducted)	UNIVERSITY OF SOUTH AFRICA
2.3 Objectives of and need for the study (Set out the major objectives and the theoretical approach of the research, indicating briefly, why you believe the study is needed.)	The primary objective of the study is to compare the meaning of the 'learnability' principles for children and adults. Through observations of children and adults learning to use computer applications l learnt that sometimes children master the application with less effort than adults. The study is indeed needed in order to make a comparison on the way in which children and adults learn to use a new application
2.4 Questions to be answered in the research (Set out all the critical questions which you intend to answer by undertaking this research.)	Does learnability of software interfaces have a different meaning for children and adults?
2.5 Conflict of Interest:	N/A

2.5 Research approach/ methods
(This section should explain how you will go about answering the critical questions which you have identified under 2.4 above. Set out the approach within which you will work, and indicate in step-by-step point form the methods you will use in this research in order to answer the critical questions).

For a study that involves surveys, please append a provisional copy of the questionnaire or interview questions and the consent form to be used. The questionnaire/interview protocol should show how informed consent is to be achieved as well as indicate to respondents that they may withdraw their participation at any time, should they so wish.

2.6 Proposed work plan
Set out your intended plan of work for the research, indicating important target dates necessary to meet your proposed deadline.

STEPS	DATES
1. Experiments in the usability lab	September 2009 - December 2009
2. Data Analysis	January 2010 – March 2010
3. Writing up of results	April 2010 – October 2010

SECTION 3: ETHICAL ISSUES

The UNISA Ethics Policy[1] applies to all members of staff, graduate and undergraduate students who are involved in research on or off the campuses of UNISA. In addition, any person not affiliated with UNISA who wishes to conduct research with UNISA students and/or staff is bound by the same ethics framework. Each member of the University community is responsible for implementing this Policy in relation to scholarly work with which she or he is associated and to avoid any activity which might be considered to be in violation of this Policy.
All students and members of staff must familiarize themselves with AND sign an undertaking to comply with the University's "Code of Conduct for Research" (the policy can be accessed at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf).

QUESTION 3.1

Does your study cover research involving:	**YES**	**NO**
Children and Adults	√	
Persons who are intellectually or mentally impaired		√
Persons who have experienced traumatic or stressful life circumstances		√
Persons who are HIV positive		√
Persons highly dependent on medical care		√
Persons in dependent or unequal relationships		√
Persons in captivity		√
Persons living in particularly vulnerable life circumstances		√

If "Yes", indicate what measures you will take to protect the autonomy of respondents and (where indicated) to prevent social stigmatisation and/or secondary victimisation of respondents. If you are unsure about any of these concepts, please consult your supervisor/ project leader.
No real names are going to be used.

QUESTION 3.2

Will data collection involve any of the following:	**YES**	**NO**
Access to confidential information without prior consent of participants		√
Participants being required to commit an act which might diminish self-respect or cause them to experience shame, embarrassment, or regret	√	
Participants being exposed to questions which may be experienced as stressful or upsetting, or to procedures which may have unpleasant or harmful side effects		√
The use of stimuli, tasks or procedures which may be experienced as stressful, noxious, or unpleasant		√
Any form of deception		√

[1] The URL for this is: http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Any use of materials harmful to human beings		√
If "Yes", to any of the previously mentioned explain and justify. Explain, too, what steps you will take to minimise the potential stress/harm.		
Participants, who will be taught to play an educational game, especially on the part of adults being taught by a child, and then fail to do it, might feel embarrassed. In this case before the experiment is carried out the researcher will inform both the children and the adults that it will not be their intelligence being tested, but the learnability of the software.		

QUESTION 3.3

Will any of the following instruments be used for purposes of data collection:	**YES**	**NO**
Questionnaire		√
Survey schedule		√
Interview schedule		√
Psychometric test		√
Other/ equivalent assessment instrument	√	

If "Yes", attach copy of research instrument. If data collection involves the use of a psychometric test or equivalent assessment instrument, you are required to provide evidence that the measure is likely to provide a valid, reliable, and unbiased estimate of the construct being measured as an attachment. If data collection involves interviews and/or focus groups, please provide a list of the topics to be covered/ kinds of questions to be asked as an attachment. Explain the withdrawal or discontinuation criteria of respondents.
A very informal interview will be carried out.

QUESTION 3.4

Will the autonomy of participants be protected through the use of an informed consent form, which specifies (in language that respondents will understand):	**YES**	**NO**
The nature and purpose/s of the research	√	
The identity and institutional association of the researcher and supervisor/project leader and their contact details	√	
The fact that participation is voluntary	√	
That responses will be treated in a confidential manner	√	
Any limits on confidentiality which may apply	√	
That anonymity will be ensured where appropriate (e.g. coded/ disguised names of participants/ respondents/ institutions)	√	
The fact that participants are free to withdraw from the research at any time without any negative or undesirable consequences to themselves	√	
The nature and limits of any benefits participants may receive as a result of their participation in the research	√	
Is a copy of the informed consent form attached?	√	

If not, this needs to be explained and justified, also the measures to be adopted to ensure that the respondents fully understand the nature of the research and the consent that they are giving.

QUESTION 3.5

Specify what efforts been made or will be made to obtain informed permission for the research from appropriate authorities and gate-keepers (including caretakers or legal guardians in the case of minor children)?
Letters will be sent to parents of the children to ask for permission to use their children as subjects of the experiment. Parents who accept are required to sign in the space provided.

QUESTION 3.6

STORAGE AND DISPOSAL OF RESEARCH DATA/SAMPLES: **Please note that the research data should be kept for a period of at least five years in a secure environmental safe location by arrangement with your supervisor. In the case of samples will the samples be destroyed?**
How will the research data be disposed of? Please provide specific information, e.g. shredding of documents incineration of videos, cassettes, etc. • Permanent deleting of files • Shredding hard copy documents • Incineration of videos.

QUESTION 3.7

In the subsequent dissemination of your research findings – in the form of the finished thesis, oral presentations, publication etc. – how will anonymity/ confidentiality be protected?
No names will be used.

QUESTION 3.8

Is this research supported by funding that is likely to inform or impact in any way on the design, outcome and dissemination of the research?	**YES**	**NO** √

If yes, this needs to be explained and justified.

QUESTION 3.9

Has any organization/company participating in the research or funding the project, imposed any conditions to the research	**YES**	**NO** √

If yes, please indicate what the conditions are.

SECTION 4: FORMALISATION OF THE APPLICATION

APPLICANT

I __Bester Chimbo__ have familiarised myself with the UNISA Ethics policy, the form completed and undertake to comply with it. The information supplied above is correct to the best of my knowledge. I have read the policy for research ethics of UNISA and the contents of my application as presented to the CREC of CSET is a true and accurate reflection of the methodological and ethical implications of my proposed study. I shall carry out the study in strict accordance with the approved proposal and the ethics policy of Unisa. I shall maintain the confidentiality of all data collected from or about research participants, and maintain security procedures for the protection of privacy. I shall record the way in which the ethical guidelines as suggested in the proposal has been implemented in my research. I shall notify URERC in writing immediately if any change to the study is proposed or if any adverse event occurs or when injury or harm is experienced by the participants attributable to their participation in the study.

NB: PLEASE ENSURE THAT THE ATTACHED CHECK SHEET IS COMPLETED

……………………………………..
SIGNATURE OF APPLICANT **DATE**

SUPERVISOR / DIRECTOR OF SCHOOL

NB: PLEASE ENSURE THAT THE APPLICANT HAS COMPLETED THE ATTACHED CHECK SHEET AND THAT
THE FORM IS FORWARDED TO YOUR COLLEGE RESEARCH COMMITTEE FOR FURTHER ATTENTION

………………………………………
NAME OF SUPERVISOR/ PROJECT LEADER
……………………………………..
SIGNATURE **DATE**

RECOMMENDATION OF COLLEGE RESEARCH AND ETHICS COMMITTEE

The application is (please tick):

	Approved
	Recommended and noted
	Not Approved, referred back for revision and resubmission

………………………………………
NAME OF CHAIRPERSON:
……………………………………..
SIGNATURE **DATE**

RECOMMENDATION OF SENATE RESEARCH AND ETHICS COMMITTEE

………………………………………
NAME OF CHAIRPERSON:
……………………………………..
SIGNATURE **DATE**

UNISA

CSET - CREC

ETHICAL CLEARANCE APPLICATIOM FORM

CHECK SHEET FOR APPLICATION

	PLEASE TICK
1. Form has been fully completed and all questions have been answered	
2. Questionnaire/interview protocol attached (where applicable)	
3. Informed consent document attached (where applicable)	
4. List of acronyms and abbreviations should be attached.	
5. Approval from relevant authorities obtained (and attached) where research involves the utilization of space, data and/or facilities at other institutions/organisations	
6. Signature of Supervisor / project leader	
7. Application forwarded to College Research Committee for recommendation	
8. A complete copy of the proposal should be available if so requested.	

Appendix D: Letter of Approval

UNISA university of south africa

Mrs B Chimbo
P O Box 1677
Pretoria
0001

To whom it may Concern

Permission to conduct Qualitative Research Project

The request for ethical approval for your research project entitled: "Comparing the meaning of the learnability principle for children and adults" refers.

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee has considered the relevant parts of the studies relating to the abovementioned research projects and research methodology and is pleased to indicate that the research process poses no ethical problems.

Therefore involved parties may also consider ethics approval as granted. However, the permission granted must not be (mis) construed as constituting an instruction from the CSET Executive or CSET CREC that sampled participants are compelled to take part in the research project. All participants retain their individual right to decide whether to participate or not.

We trust that sampling will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:

http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Yours sincerely.

Prof S Lubbe

Acting Chairperson: CREC

Prof M Setati

Executive Dean: CSET

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix E: Child consent form

Dear Parent/Guardian

I am Mrs Bester Chimbo, a Master of Science student in the School of Computing at the University of South Africa. I am conducting an experiment to determine the meaning of the Learnability principle for children and adults, working under the supervision of Prof Helene Gelderblom and Prof Ruth De Villiers. I am kindly seeking your permission to include your child …………………………………….. as a participant in this research. Please read this consent document carefully. If you grant permission for your child to participate in this study, please sign the agreement at the end of the form and return it to me.

Title of the research project:
Comparing the meaning of the learnability principle for children and adults

Purpose of the research study:
The purpose of the experiment is to make a comparison between the ways in which children from the ages of 9 to 13 years and adults (between the ages of 35 and 50 years) learn how to use a new software application.

What the experiment entails:
Your child will use one or more of the following software applications:

- Timez Attack- Mathematics Educational Game
- Story Book Weaver (2004) – English Essay Writing Educational Game
- Microsoft Outlook
- Microsoft PowerPoint

Please take note of the following:
Your child will participate either as an expert or a novice.
As an expert, your child will be observed whilst teaching another child or an adult how to play one of the software products above.
As a novice, your child will be observed being taught by another child or an adult how to play one of the software products above.
We are NOT in any way evaluating your child; we are evaluating the learnability of the software and the process of learning to use it.
All sessions will be videotaped and recorded

Venue:
The experiment will take place at Unisa, in a state of the art usability laboratory.

Time required:

We expect a session to last about 60 minutes, including – this will include an informal, semi-structured interview during which we will discuss your child's experience with the software application with him or her.

Each participant will take part in at least one session and at most four sessions.

Confidentiality:

The data collected will be used only for research purposes and anonymity will be preserved. Your child's name will not be associated with any data that are collected during this experiment.

Risks:

There are no known risks associated with this experiment.

Token of appreciation:

Participants will each receive a gift or a gift voucher.

Your child's rights as a participant are as follows:

Your child has the right to withdraw from the experiment at any time for any reason.
At the conclusion of the experiment, you may see your child's data, if you so desire.
If you decide to withdraw your child's data, please inform the facilitators immediately.
You may sit in whilst the experiment is being conducted.

Finally, we greatly appreciate your child's time and effort for participating in this experiment. Remember, your child cannot fail any part of this session, as there is no right or wrong answer. Please do not hesitate to ask if you have any questions about the experiment.

My contact details are as follows:

Email address: chimbb@unisa.ac.za
Phone number: +27129976143
Cell number: +27823338815

Agreement:

Your signature below indicates that you have read this consent form in its entirety and that you voluntarily allow your child to participate.

Name & Surname:		Contact Tel.no:	
Signature:		Date:	

Appendix F: Adult consent form

Dear ……………………………………..

I am Mrs. Bester Chimbo, a Master of Science student in the School of Computing at the University of South Africa. I am conducting an experiment to determine the meaning of the Learnability principle for children and adults. I am working under the supervision of Prof Helene Gelderblom and Prof Ruth De Villiers. I am kindly seeking your permission to include you as a participant in this research. Please read this consent document carefully. If you agree to participate, please sign the agreement at the end of the form and return it to me.

Title of the research project:
Comparing the meaning of the learnability principle for children and adults

Purpose of the research study:
The purpose of the experiment is to make a comparison between the ways in which children from the ages of 9 to 13 years and adults (between the ages of 35 and 50 years) learn how to use a new software application.

What the experiment entails:
You will use one or more of the following software applications:

- Microsoft Outlook
- Microsoft PowerPoint
- Timez Attack- Mathematics Educational Game
- Story Book Weaver (2004) – English Story Writing Educational Game

Please take note of the following:
You will participate either as an expert or a novice.
As an expert, you will be observed whilst teaching a child or another adult how to play one of the software products above.
As a novice, you will be observed being taught by another adult or a child how to play one of the software products above.
We are NOT in any way evaluating you; we are evaluating the learnability of the software and the process of learning to use it.
All sessions will be videotaped and recorded.

Venue:
The experiment will take place at Unisa, in a state of the art usability laboratory.

Time required:

We expect a session to last about 60 minutes – this will include an informal, semi-structured interview during which we will discuss your experience with the software application.

Each participant will take part in at least one session and at most four sessions.

Confidentiality:

The data collected will be used only for research purposes and anonymity will be preserved. Your name will not be associated with any data that are collected during this experiment.

Risks:

There are no known risks associated with this experiment.

Token of appreciation:

Participants will each receive a gift or a gift voucher.

Your rights as a participant are as follows:

You have the right to withdraw from the experiment at any time for any reason.
At the conclusion of the experiment, you may see your data, if you so desire.
If you decide to withdraw your data, please inform the facilitators immediately.

Finally, we greatly appreciate your time and effort for participating in this experiment. Remember, you cannot fail any part of this session, as there is no right or wrong answer. Please do not hesitate to ask if you have any questions about the experiment.

My contact details are as follows:

Email address: chimbb@unisa.ac.za
Phone number: +27129976143
Cell number: +27823338815

Agreement:

I have read the procedure described above. I voluntarily agree to participate in the experiment and I have received a signed copy of this description.

Name & Surname:		Contact Tel.no:	
Signature:		Date:	

Appendix G: Collection of Observation and Interview Data

What to look for in the videos and interviews:

Of major importance from this study are the insights it will provide into aspects of software interfaces that adults and children struggle with. Such insights will be critical in giving software-designers an idea of how best to correct or improve their products in such a way that eliminates the elements that hinder the users. The end result will ultimately aid in the reformulation of the learnability principle in a way that distinguishes between adults and children.

Therefore the characteristics I will look for in the videos will be guided by the following statements or questions:

- Identify aspects of software interfaces that adults/children struggle with those children/adults have no problems with.
- Children's/adults' prior experience influences their interaction with computer applications.
- Identify the kinds of applications that adults/children find difficult or easy to learn.
- What specific behavioral difference (emotional reactions) can be observed?
- Does eye tracking show any differences in behavior between adults and children?

Observations from video recordings

The table below contains extracts from the (unedited) transcriptions taken during repeated viewing of the video material.

Software	Expert Child	Novice Child
Timez Attack (novice taught by expert)	**CE_1**: Demonstrated how the game was played. She shows **CEN_2** the stages she has won, which ranges from 1 to 12. Yes and you have to do those again. 3 times table is my favourite. First get the spiders and throw them then do the multiplication tables. **CE_1** laughs and says so funny and repeats pressing the button "W" over and over again making the avatar jump. And then you can go dup (multiplying numbers). Let me die!! Let me hear again. I already know 2 and 3 times table by heart. Can you believe! When the calculator asks you then she laughs. Asks you three times per level. If you give the wrong answer then the monster will shoot you. You just go back and look for the number. You must remember the sums coz at the end you will be asked all of them. **CE_1** is watching: **CEN_2** uses the wrong hand to click and **CE_1** says No! No! No! then shows **CEN_2** the right door. You can go back and she shows what is to be done. Even if you do not use your hand should stay on the mouse.	**CEN_2**: Asked questions: It actually tells you how many you got right? If you get it wrong then it shows the red line? What if the avatar falls? **CEN_2** tells **CE_1** that she has noticed that if you throw those things it will give you sums and one of the sums is the right answer. That was weird! So it means l can go down again (showing action using hands). So it's like fighting Mastered the game immediately and did not struggle with the mouse. "W" Go through the snails. What if you make a mistake of where you have to go? **CEN_2** takes over: I think l am gonna try. She starts by mentioning what the letters stands for: Forward is "W" She uses both hands for typing numbers when giving answers. Then switches over to one hand on mouse and the other on the keyboard. Makes more use of both hands on the keyboard. Struggling with the mouse.
	CE_1: **CE_1** starts by telling **CN_4** that they need to save the game in her name. Demonstrated how the game was played. To walk you press "W" The avatar walks down the passage until you get to a times table. Snails pop up and then you have to catch them. Then once that is done you do the times tables. The creature comes out and she does the answers to the multiplication tables shown on the screen. The creature disappears and you get the key to open another door. **CE_1** says sorry and explains that you can press F or the left button on the mouse. To find the door you look around you will find one with numbers to multiply. We have reached the checkpoint. The next stage comes and **CE_1** fails to catch the snails. She sighs and says "l feel so stupid".	**CN_4**: Asked a few questions. Understood all aspects of the game with the first demonstration. Everything was easy to do. **CN_4** asks how you catch the snails. What name is given to the monster? **CN_4** takes over: How do l go back? **CE_1** explains: A is Left B is right W is Walk F throwing **CN_4** repeats what she has been told. When she sees the snails she asks how she would catch them. **CE_1** explains that she has to go forward and catch them. **CN_4** struggle a bit to catch the snails. When the monster comes **CN_4** writes

	CE_1 tells **CN_4** that there are 3 different things namely: • The dungeon • The robot a lot of machinery and • ----? And each one has a different world. Dragon If you get the number wrong the dragon kicks you. **CE_1** explains the meaning of the bars which appear on the game: Red bar: How much you are left with. Yellow bar: It is the time you take to answer the multiplication tables. Every time you punch an answer the red goes to the left and the yellow continues also to go to the left until all the answers have been given. The avatar gets to a certain area which **CE_1** says it is like an elevator taking the avatar to other places. **CE_1** tells **CN_4** to tell her when she is ready to play.	the wrong number and the avatar is beaten by the monster. **CN_4** smiles when she reaches the check point and is congratulated. When she continues playing the avatar falls into the ditch. **CN_4** puts her hand on the mouth with shame, but **CE_1** tells her that it is okay. She continues and shows that she is enjoying the game by smiling every time she brings the monster down.
	CE_1: She told **CN_3** she would show her how the game is played then it will be **CN_3**'s turn to play. **CE_1** demonstrated how the game is played. "W" Walk forward "S" Walk backwards "B" Move to the right "A" Move to the left Spacebar is jump They are both puzzled to discover that they are being congratulated for reaching the checkout point and yet they have not done anything. **CE_1** gets to the door with numbers and tells **CN_3** that she has to remove the snails first by throwing them at the door. **CN_3** asks how this is done. **CE_1** tells her that you do that by clicking the left button on the mouse or F. Then you calculate the tables on the monster until it disappears. You then get a key for the next door. Yellow bar: How much time you have taken. Red bar: How much time you have left. **CN_3** asks if there is a time limit on the appearance of the bars. **CE_1** is not sure, but says probably 5 mins. When you catch the snails it usually tells you the answer of the multiplication table on display. **CN_3:** What if you run out of time? **CE_1** did not answer.	**CN_3**: Asking questions while demonstrations were in progress. **<u>Chn pay</u>** more attention when being taught. **CN_3:** Does it matter which numbers l use on the keyboard? **CE_1:** It does not matter, but you are more comfortable using the ones on the right hand side. **CN_3:** How many times do they ask you to do times table each time? **CE_1:** Every time it asks you three times. To open the door it asks you once then when the monster is there it is three times. **CN_3**: Can you go the wrong way? **CE_1**: You just go the other way. **CN_3**: Will you realize that you are going the wrong way: **CE_1:** Usually if you go the wrong door it will not open, so you have to look for the door that will open. **CN_3**: Can you miss the snails? **CE_1**: You will not be able to type the answers, so you need to find the snails. **CN_3:** How many of these monsters have you to defeat? **CE_1**: She is not sure how many times. **CN_3**: Why do you need the jump key?

	CN$_3$: Which times table does it ask you? **CE$_1$:** From 2 to 12. After each times table there is a big test. **CE$_1$:** After destroying the monster you go to the bigger run, the winning door then you are asked everything you have learnt in different order. **CN$_3$:** How many lives do you live? It's not like ---if you choose 2 you do not die you fall. Other times you just fall then everything turns black then you live again. So you have lots of lives you just go on living.	**CE$_1$:** If the way is at a higher level then you have to jump to get there. Or if there is lava, you do not want to fall into it you have to jump and cross it. **CN$_3$**: Do the times table get harder? **CE$_1$**: Yes they do, but they ask you randomly. **CN$_3$**: How do you know that you are done with the 2 times table? **CE$_1$**: There will be a very long passage which you go round and round and there is a very huge monster that asks you times tables. Emotions: Very serious looking and at the same time enjoying the game.
	Expert Child	**Novice Adult**
Timez Attack (novice taught by expert)	**CE$_1$:** Explain navigation Demonstrated how the game was played. Press Mouse or F key? **CE$_1$** mostly response to questions from **AEN$_3$** rather than offering information. You cannot type before throwing. **CE$_1$** points to the line when you type and says something. **CE$_1$** says she always gets scared when she gets to the turning bridge. When they got to the 3rd or 4th sum (7x3) **CE$_1$** explains again the different options of using the keys. Change to new easier game. **CE$_1$** answers that it is because she has played often. Now **CE$_1$** also explains what the red and yellow bars mean at the top (when you are answering questions). (A bit distracted) but says yes you just get the key otherwise, you will not get to the door. You must throw it. **CE$_1$** presses the backspace key for her.	**AEN$_3$:** First asks what you must do How did you throw it Difficulty moving the mouse. Would laugh or shout nia (no) whenever she failed to accomplish a stage. Catching snails. Questions asked: Do you still not give the answer? What if you just type answer without throwing first? How do you now know that you can immediately type the answer?. Oh! Oh! Oh! Mmm! on **CE$_1$**'s behalf when she falls 3 times in a row. When the avatar jumps of at the hole in the floor **AEN$_3$** asks how she knows she can now jump (and won't fall like in the other scenario). Must you grab the key as well. When **AEN$_3$** was playing, when confronted with sums she does the following: Sjoe! Ok what now? Oh gosh – how now? Where is it now? Oooooooohmmm!!! Laughs My motor skills are not good. **AEN$_3$** laughs. Has to wait for new snails. **AEN$_3$** struggles for very long to catch a snail.

		Throws successfully but then makes typing error. "How do I delete!" **AEN$_3$** answers 3 sums successfully. Starts walking. How now? How now? Cannot turn avatar **AEN$_3$** laughs. **AEN$_3$** catches snails easily and throws and answers. Goes on successfully for a while. Still struggling to catch the snails I do not have a clue where l am now.
	Expert Child	**Novice Adult**
Timez Attack (novice taught by expert)	**CEN$_2$:** Demonstrated how the game was played, but goes to the wrong door and corrects it. She then explains what the letters stand for. When **AN$_2$** was playing she was told what to do, where to go. She was told every step she needed taking. I can teach Rutendo. You have to catch the snails. By walking over them. Told **AN$_2$** either to press "F" or this one. Now get the key. Turn your mouse and press "W" Go back back, turn your mouse to face the key and press "W" Turn your mouse. Let's go straight Wait wait go back go back. You have to finish the level. Quick turn this side l did not see what's on that side.	**AN$_2$:** Struggled using the mouse. You keep on pressing the wrong door, When you are given the Experienced difficulty turning the mouse. She was laughing throughout the game. She asked which direction? When she go to the numbers at long last she shouted: Oh finally!! How do l catch them? When told to write the number **AN$_2$** laughs and said Yo! this is fun. How do l get the key? Yo! The mouse is refusing to turn. OK! You see now. Claims that the mouse refuses to turn. But l am going down into this thing. Struggled to find the right door. Key now getting the key. Finally when she reached checkpoint she hit the table with satisfaction and said yo!!.
	Expert Adult	**Novice Adult**
Timez Attack (novice taught by expert)	**AE$_1$:** **AE$_1$** asks **AN$_4$** if he knows anything about the game then he says No. **AE$_1$** explains that It is software for children who are 7 to 11 years old which teaches them about times tables. Basically it takes you through 2 times table up	**AN$_4$:** Difficult: Walk with the mouse Keeps asking for help from expert Frustrated: when failing to catch snails: Says Ahaha! Failing to find the right door. Easy:

	to 12. She starts by giving the instructions and demonstrating how the game is played. She points at the avatar and says basically that is you and you have to pass through doors whilst multiplying numbers. She tells him that you will come to an Ogre who will also give you times tables which you need to give answers and when you have finished the Ogre will give you a golden key to move to the next door. You have to go through all the doors until you get finish 2 times table then you get a test to take you to the next times table, where you will meet a more vicious Ogre. She tells him he can use a mouse to turn or arrow keys. She finds it easier to turn with a mouse and walk with the arrow keys. Jump use the space bar. **AN_4** asks what to use when turning? **AE_1** says you turn the mouse like a steering wheel. To find the door it is not always easy. **AE_1** finds it funny that she is congratulated for reaching the check point when she hasn't done anything Also had difficulties walking with the mouse.	Turn with a mouse and walk with a key. Multiplying numbers. **AN_4** cannot figure out where he was. **AE_1** mentions that her children seem to remember where they were as soon as possible yet she can't. **AN_4** can move the avatar better than before. He is about to give up, **AE_1** told him not to give up, but to keep on trying. He finally gets to the end of the game but fails to catch snails. **AN_4** is laughing and he says the avatar is running away. He multiplies the numbers which comes out of the creatures. When the creature disappears he is happy and says it is high time it dies. **AE_1** reminds **AN_4** that there are a number of doors he has to open and he agrees. **AE_1** says the program is not nice. She then tells that he now take the test. She tells him that it keeps on going until he is tired. He says the wall is moving. **AE_1** asks what the two grey buttons means?
	Child	**Adult**
TimezAttack (self-taught)	**CN_{10}:** **Difficulty:** Nothing was difficult. Not reading instructions at the bottom of the game. **Easy:** doing the times tables. Moving the mouse, when moving the avatar **Emotions:** Umm! Oops!	
		AEN_5: Difficulty using the mouse. Struggling to catch the creatures. Using two hands to type answers. Emotions: Frustrated when failing to collect snails. Umm when figuring what to do. Uwee when he knows what to do. Ola and Ahi when he defeated the creature. Some of the words used: **Got you! Hey! Oh my! Good boy!**

		Ah! Die! Feel the pain! Singing in satisfaction. Ah come on when multiplication tables appear again Laughing at the creature.
		AN_{11}: Read tutorials first. Difficulty: Finding the correct door, Could not figure what to do on her own Struggling to collect snails. Easy: Emotions: Laughing when failing to catch the snails. Oh Ok! When figuring what to do. Keeping on moving the keyboard. Slow to figure out the next step. Questions asked: How do l make the avatar walk to the left?
	CEN_8: Played the game well A bit slow on chasing after snails, but did enjoy everything about the game. Wanted to continue playing the game	
		AN_{10}: Memory is full? Started by reading instructions. Decide to follow tutorials. Difficulty: Difficulty in finding the right door. Mouse navigation Frustration: Frustrated because of failing to catch the snails. Easy: Multiplying the numbers. Emotions: Laughing after clicking wrong button. Scratching head when trying to figure out what to do next. Ah! Grief on failing to find the right door. Oh my and laughing. Must l put the number in? What? Where are the snails? Can you help me? Oh good grief! How many are they? No! Oh man! When thinking that you have

		collected all the creatures and another one just appears. Had to be helped to collect all the snails. Oh great when the monster disappeared. Yeh! When finally managing to catch the snails. Oh no still wanted to continue. Come on you silly thing! Man! Bingo! At last! Right! I am totally drunk.
	CEN_7: Difficult: Ah when he fails to move the avatar at the right place. Easy: Finding the right door. Good control of hand and mouse. Emotions: Laughing at the monster	
		AN_{12}: -First clicked on tutorials. -Read through the tutorials with hand on the cheek as if troubled by something. -**AN_{12}** would laugh at himself and scratch whenever he failed to do something. -Struggled to get rid of the creatures. -When he did finally he raised hands in the air. -He would ask what he is supposed to do next. -Enjoyed playing the game
	Expert Child	**Novice Child**
StoryBook Weaver (expert teaching novice)	**CE_5:** **CE_5**: Starts by asking **CN_6** the title she wants to give. **CE_5**: Now you go to create background. **CE_5**: Which background do you like? **CN_6:** Take the butterflies. **CE_5:** Now if you want to have them you click the (+) button. **CE_5:** Do you like it? **CN_6:** Yes **CE_5:** Now you have to choose one of these. Which one do you like? **CN_6:** She chooses. **CE_5:** Now you click on animals and choose the	**CN_6:** **CN_6: CN_6** is a fast learner. She was able to do what **CE_5** demonstrated in one go. This is shown in the story and the pictures she put Check her video. **CE_5:** showed her how to go to the next page. **CE_5:** Showed her how to save her story. **CN_6** showed that she knew what she was doing and she was full of confidence when creating her story. **CN_6:** did not struggle with anything except that she tried to paint her

	animal you like. She first shows the different kinds of things there. **CE_5:** Get all the horses you like. **CE_5:** If you want to change colour you can get the colours you want. **CN_6:** I want Brown colour. **CE_5:** Could not get the colour Brown she wanted on the colours there. **CE_5:** Took grey, but it was difficult for them to change the colour. Instead of the colour going on the horse it coloured the background and it was difficult for them to change the colours. **CE_5:** You can change the size. **CE_5:** demonstrated how you can put music. **CE_5:** demonstrated how you can get sound. **CE_5:** demonstrate how a story is written at the bottom of the picture. **CE_5:** if you do not like anything in the picture click on it and throw it away. **Software:** Both wrote a wrong spelling and the game does not have the facility to show that a wrong spelling has been written or just to correct.	unicorns, but could not figure out how to do it.
	CEN_2: **CEN_2**: Starts by explaining that she first writes title of her choice. **CEN_2:** The author can be yourself or the book you have read. **CEN_2:** Comment you can leave it by just pressing enter. **CEN_2**: Now you go to create background. **CEN_2**: You can mix the background by taking the backgrounds on different parts. **CN_9:** So you have to use all the backgrounds? **CEN_2**: No you choose what you want for your picture. **CEN_2:** Now if you want to have them you click the (+) button and then the tick. **CEN_2:** Now you have to choose the pictures you like for you story. **CEN_2:** Now you click on the Pictures you like and spread them. She first shows the different kinds of things under pictures. **CEN_2:** You can decorate by putting plants and trees depending on what your story is all about. **CEN_2:** Demonstrate how a story is written at the bottom of the picture. **CEN_2:** If you want you can go to goodies and then anything in the picture click on it and throw it away. **CEN_2:** She showed **T** how to save her story. Software: Goodies Menu failed to do what **CEN_2** wanted to demonstrate.	**CN_9:** **CN_9: CN_9** started off well without problems. **CEN_2:** There are more background pictures, you can scroll and choose what you want from the range. **CEN_2:** You can put a picture on your title page if you want of a book or anything you like. **CN_9:** I do not want to put a picture on the title page but on the other pages. **CN_9:** Went straight to pictures on the next page. **CEN_2:** Wait! Go to background first. **CN_9:** She chose two bottom backgrounds. **CEN_2:** You have to choose a bottom and top backgrounds not 2 bottoms or the other way round. **CN_9:** Where is that other bottom? **CEN_2:** You can only put one at a time. **CN_9:** She chooses the pictures she wants. **CEN_2:** To close the picture menu when you are done with it you press button with tick. **CN_9:** I do not need the other pictures so what do l do? **CEN_2:** Press one at a time and press the dustbin button. **CEN_2:** Showed her how to save her

		story. **Creating one more story:** **CN_9:** Creative, choosing backgrounds that go together with the title. When she fails to do something she opens her mouth wide. When she does well she smiles. **Software:** If the author does not put a capital letter where it is supposed to be the software does not automatically correct that for you.
	CEN_7: **CEN_7:** First explains to **CN_3** that you are supposed to create a story. **CEN_7:** Clicks on the "create a story" button. **CEN_7:** On other you can write your name. **CEN_7:** You can put a comment there. **CEN_7:** Now you create the background you want. **CN_3**: Which background do you like? **CN_3:** Take the caves. **CEN_7:** Go to the nest page and again choose your backgrounds at random. **CN_3:** They do not look the same. **CEN_7:** Chooses another background. **CEN_7:** Goes to the next button, then tells **CN_3** that here you choose the objects of your choice. **CN_3:** Take animals. **CEN_7:** Shows various types of animals given. He chooses bears. **CN_3:** Wow! **CEN_7:** You can click and drag them to the positions you want them to be. **CN_3:** Can you make the animals smaller and stuff? **CEN_7:** Yes you can and **CEN_7** shows the button you can use to make them smaller or bigger. **CEN_7:** If you want l can teach you how to make a reflection of the pictures. **CEN_7:** He presses a button making the bears upside down. **CN_3:** If you want to delete a picture can you do so by pressing delete or throwing in the trash bin. **CEN_7:** Now if you want to make changes to your picture you can click the pencil and make changes. **CN_3:** What are all those buttons representing? **CEN_7:** Paint brush, an eraser and the other button you can use to put a part aside and do changes to that part only. And a magnifying glass. **CN_3:** laughs at the part where part of the picture	**CN_3:** **CN_3:** She writes a title and says "Here we go". **CN_3** had already mastered all **CEN_7** had demonstrated because she could use all the buttons to create her story **(View video).** **CN_3** had difficulty choosing the music to take because she liked all those she tried. **CEN_7:** Explains that on Sound you have to click first on the object you want the sound to come up from and choose the sound. **CN_3:** On the next page she chooses another background. **CN_3:** This looks cool! **CN_3:** enjoyed every bit of the game and plans to ask her parents to purchase the software for her.

	is cut. **CEN$_7$:** When you are done working with your picture, you press the magnifying glass, and then return to the pages where you are creating your story. **CN$_3$:** Cool! **CN$_3$:** So when you are done you just type a story. **CEN$_7$:** Types a story. **CN$_3$:** asks what the other buttons represent? **CEN$_7$:** There is a sound button then he puts sound. You can attach the sound to a character. **CN$_3$:** She dances to the sound of the music. **CEN$_7$:** This is a microphone you can also record what you want. **CEN$_7$:** Demonstrates how to record one's voice. **CN$_3$:** Is very excited by this. **CN$_3$:** She tells **CEN$_7$** what each of the button stands for and where she has forgotten **CEN$_7$** helps. **CEN$_7$:** Shows **CN$_3$** how she can save her work. **CEN$_7$:** Shows **CN$_3$** how to get started as given by the software. **Software:** The buttons are many and if you are a beginner it is difficult to master what each one stands for. It would be better to have a pop up message which just come when one points on each button. The software shows at the bottom the instructions and one might not see that. All were not confident with writing a comment.	
	Expert Adult	**Novice Child**
StoryBook Weaver (expert teaching novice)	**AE$_1$:** **AE$_1$:** Starts by showing the demonstration page. **AE$_1$:** You can open the story already written then read, also shows her how to load a story. **AE$_1$:** Then goes to click on the create a story button. **AE$_1$:** Demonstrate what should be on the title page. **AE$_1$:** You can decorate the title page by going to the background buttons. You can now choose the choice of frame you like. **AE$_1$:** This is one of the usability problems-----? There are many and you have select one of them. **CEN$_8$:** What is the tick for? **AE$_1$:** That is if you have chosen your frame, you can click to show that that is the one you want to apply. **AE$_1$:** You can now start on your story page by paging through the next pages.	**CEN$_8$:** **CEN$_8$: CEN$_8$** on her title page gives a comment about the best book to buy. **CEN$_8$:** Follows all the steps demonstrated to her by **AE$_1$** and creates a story. **AE$_1$:** Tells **CEN$_8$** that when you want to use the sound button and the others below you need to select the picture so that you will be able to use the buttons. **CEN$_8$:** Very creative, she came up with very nice pictures.

	AE_1: On the story page you choose a background. I always choose backgrounds that go together, but you are allowed to mix them up. **AE_1:** After background you then add objects you want to use. There are various categories, and sub-categories you can choose any category you want. **AE_1:** You can improve the characters you have chosen by using pencil button to add features to the characters chosen. **AE_1:** If the software was installed properly, on goodies you would be able to change your text to voice then someone using a funny American accent would read your story. **CEN_8:** Asks what the other buttons stand for and **AE_1** explains. **Software:** The resolution is not good. You cannot edit on one window when another one is open, you have to close the one on top to be able to edit the bottom window. You cannot delete the music if you no longer like it. Colour is difficult to edit. No slide show. Distorts what one has written on the title page when one goes to the nest page.	
	Expert Child	**Novice Adult**
Microsoft Outlook (expert teaching novice)	**CEN_8:** **CEN_8:** Shows AN6 examples of emails received, those that were send and those that have not been read. **CEN_8:** She demonstrates how one can send an email. **CEN_8:** First, you need to type the email address of the person you are sending mail. You can also use the address book or check names if you are not sure of the addresses you are sending mail. **CEN_8:** On subject you type what the email is about. CC is putting an email address of a person you also want to receive the email you are sending. Then on the message box you write whatever message you want to write. You can change the font, size and colour of your message. **CEN_8:** You can attach files and items to your email. **CEN_8:** You can also include business cards or signature to the email you are sending. **CEN_8:** Follow up is when the message has to be	**AN_6:** **AN_6: AN_6** types a message, but **CEN_8** assist him again all the way through. **AN_6:** Now he wants to send a new email and has **CEN_8** showing him the way to do it. It was difficult for him to master everything though **CEN_8** had demonstrated it so well.

	responded to. **CEN$_{8}$: CEN$_{8}$** explains that: A mailbox is a letter box for electronic mail it is where electronic mail messages are delivered. Deleted items are the messages you no longer need and you put them in a trash bin. She explained what everything on the left pane stands for (View video). When **CEN$_{8}$** was demonstrating **AN$_{6}$** was responded "OK" all the time.	
	Expert Adult	**Novice Child**
Microsoft Outlook (expert teaching novice)	**AE$_{1}$:** **AE$_{1}$:** Have you used any email before? **CN$_{10}$:** No. **AE$_{1}$:** You do not have email at home? **AE$_{1}$:** Do you know what email is? **CN$_{10}$:** No. **AE$_{1}$:** Email is a way of sending message between people over the internet. **AE$_{1}$:** This is how our email system looks. These are all messages received. I have my own account, Marco has his own and **AN$_{2}$** has her own account. Anyone with an internet connection and an email address can send mail to anyone with an account as well. **AE$_{1}$:** These are messages received. To read you need to double click. Can you double click? **AE$_{1}$:** Now you want to reply, which button would you press? **CN$_{10}$:** Replay to All. **AE$_{1}$:** There are two things. Sometimes a message is send to many people and if you want everybody to read your response then you use reply all, but if you want only the sender to read, then you press reply. **AE$_{1}$:** If you click reply it opens up a screen where you can type the message. **AE$_{1}$:** In the "To" box you type the email address of the person you are sending mail. But because this is a reply it automatically shows you the name of the person you are replying to. **AE$_{1}$:** Cc is putting an email address of a person you also want to receive the email you are sending. **AE$_{1}$:** Then it says "Subject" you cannot leave this open because you want to let the reader know what the message is all about. **AE$_{1}$:** Now type a message and send. **AE$_{1}$:** Now this is what you do when you reply to a new message. Now let's say you have a new friend you want to send a message, can you figure out what button to press?	**CN$_{10}$:** **CN$_{10}$** now tries to send a message without the help of the expert. **AE$_{1}$:** If a name is stored in a database, so when you start typing and the address you want pops up just click on it. **CN$_{10}$:** Then l go to subject. **AE$_{1}$:** I want you to try something, write a wrong spelling on the address and see what happens. **AE$_{1}$:** If you make a spelling mistake the message is not send. You will receive a message which says that delivery has failed to these recipients or distribution lists. **CN$_{10}$:** Cool. **CN$_{10}$** was able to send emails with confidence.

	CN_{10}: New. **CN_{10}** click on new and a new page comes up. **AE_1: AE_1** shows **CN_{10}** other types of email addresses used by other countries, e.g. American email addresses ends with .com and UK ends with .uk **CN_{10}:** Types and send a message. **AE_1:** You can click on the send button then check the message items you have send. **AE_1:** You can forward a message you have received to someone else. **CN_{10}:** How do you go back to see what you have been doing? **AE_1:** Click the back button.	
	Difference in the way a child teaches and adults teach OUTLOOK.	
	Expert Adult	**Novice Adult**
Microsoft Outlook (expert teaching novice)	**AEN_5:** **AEN_5:** I am going to show you how the email program works. **AEN_5:** Have you worked with computers before? **AN_7:** Yes l have used a computer before. **AEN_5:** So you know what is a computer, mouse, keyboard and monitor? **AN_7:** Yes l know a computer, mouse, keyboard and monitor. **AEN_5:** What l am going to do is to show you how an email works. Before we start do you understand what an email is and what it does? **AN_7:** It has something to do with sending a message. **AEN_5:** It carries the same principle as sending a sms on a cell phone, or writing and posting a letter via post office. The only difference is that this is done electronically. **AEN_5:** We have a program which helps us write, send and receive emails which is called email reader. There are a couple of things we need to know or need to have to help us this program. In the same way as we need an address to send a letter, we also need the address of the person to receive the email. **AEN_5:** He shows **AN_7** were an email address is written and an example of an existing email address. **AEN_5:** Asks to click on the outlook icon. **AN_7** did. **AEN_5:** He shows **AN_7** all messages received. He shows **AN_7** where the email is coming from, and that subject refers to what the email is all about, when did you receive it. **AEN_5:** The message selected is the one	**AN_7:** **AEN_5:** Do you have an address of friend who can send an email? **AN_7:** A friend **AEN_5:** Asks **AN_7** to send a message. **AN_7:** Can we do it together again then l can later do it on my own. **AN_7:** Clicks on "New" and starts typing the address and it pops up in blue. **AEN_5:** The system is very clever; when you start typing an address already in the system it shows you the full address so that you do not have to retype it. **AN_7** has gained some confidence and is writing an email. He keeps on asking for help in the parts he has forgotten. After that he send mail. **AEN_5:** Let's say you want to answer the mail you have just received, you click on reply and the address of the person is automatically written on the "To" area. If you look at the bottom you see the message you send and the message you are responding to appearing. This helps you with the reply. **AEN_5:** Is there anything else? **AN_7:** He is satisfied and happy with what he has learnt. He looked nervous at first, but looked confident at the end.

	appearing at the bottom. **AEN_5: AEN_5** demonstrates how **AN_7** can move a message. **AN_7** tried do it and succeeded. **AN_7:** Smiled and said "Okay" **AEN_5:** An email program is like a two way thing, you send and receive emails, just like a Post Office, you receive something from the post box and you also sent letters. **AEN_5:** Any questions you want to ask? **AN_7:**x is for closing a program **AEN_5:** The icons we have can be used as shortcuts. If you click icon "New" will take you to a new email page. **AEN_5:** Asks **P** to type an email address. **AEN_5:** We **MUST** always put an address under "To" otherwise out email will not go anywhere. **AEN_5:** Do not worry about Cc. **AN_7: AN_7** then types a message in the message box and sends the message. **AN_7:** He smiles with satisfaction on seeing his email send. **AN_7:** When he receives a reply of his send message he smiles and says "Cool".	
	Expert Child	**Novice Adult**
Microsoft PowerPoint (expert teaching novice)	**CE_1:** She opens the PowerPoint program. **CE_1:** At first you have to click on "Format, then click on "Design" and pick any design. **AN_8:** What is written under design? Oh recently used. Ok choose a design you like. **CE_1:** Let's take that on. **AN_8:** That's a bit busy. **CE_1:** Now you must enter title. So what title should l write? **AN_8:** Parking at Unisa. **AN_8:** On the title can l change the font. **CE_1:** Yes you can change font, size and many other things. **AN_8:** What about Showcard Gothic? **CE_1:** Then **CE_1** types the subtitle given by **AN_8**. **CE_1:** Then click to create a next page. **AN_8:** I can't just go down? **CE_1:** No. Then **CE_1** asks for the title of the next page. **AN_8:** TVW Building. **CE_1:** She types the information given by **AN_8**. **CE_1:** You can use ClipArt to get pictures to add in your slides. **AN_8:** How do l get the pictures from ClipArt do l drag it or what do l do. Otherwise how do l put it in the right place. **CE_1:** You can drag it.	**AN_8: AN_8** followed all the steps which **CE_1** did. He would ask questions where he required help. He started by opening a new slide then went to format and chose the design he wanted **CE_1:** On clip chart **CE_1** told **AN_8** to drag pictures he liked. **CE_1:** Crop your pictures. **AN_8:** It does not want to. **CE_1: CE_1** did it for **AN_8** and it worked. **AN_8:** Yes!!! **CE_1:** Helps **AN_8** to create another page. **AN_8:** He asked if he could just drag the pictures to the new slide. **CE_1:** You right click on the picture and copy it then paste to the new slide. **AN_8:** Good!! What is different now, why did it work this time? **CE_1:** First time it said copy here, but l think they meant copy and paste, **AN_8:** Created another slide and copy and paste picture on a previous slide. **AN_8:** How do l take the background on the picture? **CE_1:** If you need to put text on the

	AN_8: How do l size the picture? **CE_1:** You can click on it and format it. **AN_8:** OK! This is lovely. **CE_1:** You then go to custom animation. **AN_8:** How do you get the Custom Animation? **CE_1:** You go to Animation and click custom animation. **CE_1:** There are many animations to choose from. **CE_1** shows them to **AN_8.** **AN_8:** Laughs at the animations shown and always says “OK”. He then chooses the one he liked most. **CE_1:** Then when you are done you can go to slide show. **AN_8:** What is the difference between a slide show and animation? **CE_1:** The difference is that slide show is between slides and animation is per slide. **AN_8:** “OK” **CE_1:** So slide show will be doing all the custom animations applied on every slide. **AN_8:** Is laughing with satisfaction as the slide show plays. **AN_8:** Where did you get that background? **CE_1:** It is from Format then slide design. It comes on your first slide then the other slides will get the same background.	picture, you double click, then go to color washout and then click okay. **AN_8:** Oh OK! Then what do l do next? Can l write? **CE_1:** No. Click on insert, then text box, then type what you want. **AN_8:** Aaa!! Now l want to do a slide show and custom animation. He chooses some slide shows and says l like that. **CE_1:** lf you want to change the arrangement of your slides you can drag them. **AN_8:** Had slide show of his slides and was so excited by it.
	Expert Adult	**Novice Adult**
Microsoft PowerPoint (expert teaching novice)	**AEN_3:** She first displayed a completed slide. **AEN_3:** This is what it will look like at the end. So that is what we are working towards. **AEN_3:** Now to start with you take a new slide and what l will do is copy and paste to the new slide the information on the old slide. **AEN_3:** To edit what you have pasted you use the functions you use in Word, e.g. font. **AEN_3 :** We have two sides on a PowerPoint screen, the left hand side one is the one you can select and see what you have on each slide, you can switch between slides. The right hand side one is the one you edit or add more information on. In other words on the right hand side is where you work on **AN_9:** Oh! I see. **AN_9:** When l choose the font size how do l know that l have chosen the right font size? **AEN_3:** You can do by trial-and-error. If the written part goes beyond the dotted lines surrounding the writing area then you need to reduce the font size, if there is still space to the dotted lines then increase the font size. Keep your sizes consistent per slide. Remember not to go smaller than 16.	

	AEN$_3$: Now l want you to create a new slide. I want you to create this slide between already existing slide. You can just click between the slides. **AN$_9$:** Oh! Ok. Alright! **AEN$_3$:** Now edit this slide by typing the information you need for the slide. **AEN$_3$:** Remember to work with a minute on a slide, that is, the information you put on each side must take toy a minute to present. **AN$_9$:** Ok! Aha Aha! Oh l see! **AN$_9$:** Is it possible to print slides? **AEN$_3$:** It is you can just go to print and choose the options you want whether to have two or four slides on each A4 size paper. Remember to produce something readable and also remember to be economical. **AN$_9$:** Can l use any design provided? **AEN$_3$**: You can use the corporate ones or use the ones already provided, but try to make sure you do not use those that are too busy, because you do not want to distract your audience. **AEN$_3$:** There are other things you can do with PowerPoint, custom animation, and slide transition. I only use them if it is functional; never use them if you do not deem it necessary. I use them when l am demonstrating a web page to people, l will simulate something that is on the webpage or when l have to go from slide to the other slide especially from bottom up. Then it becomes functional, otherwise l do not just use animation for the sake of using it. **AN$_9$:** I do not know how l can use PowerPoint to meet my needs e.g. like in a subject l need to use drawing which have step to step activities can l do that? **AN$_9$:** Can l also click from word and paste it on to my slides? **AEN$_3$:** Yes you can do that. **AEN$_3$** demonstrated how to do so using the drawing tool. **AN$_9$:** Can you also control animation? **AEN$_3$:** Yes you can place it on slow, medium and fast. **AEN$_3$:** Now what you need is go and do it on your own. You will learn a lot if you try everything alone. **Software:** 2003 and 2007 interfaces are different and the 2007 one is user friendly.	

Appendix H: Data Collection Notes (Unedited)

Below are some unedited extracts from notes made during data collection to illustrate the data collection process. The notes are organized according to the software packages.

Timez Attack (How the expert taught the novice)

Child Expert

- Instructed novice players what needed to be done before playing for the first time.
- The child expert generally responded to questions rather than offering information when demonstrating to adult novices. However, the child expert gave step-by-step demonstrations to child novices on how the game is played.

-Allowed the child novices more time to learn the game, letting the child novices to play only when they felt ready to do so. To the adult novice, the child expert demonstrated how the game is played once and asked adult novice to play the game as demonstrated.

-When it was the turn for the novices to play, child expert would just watch novice child playing, with very little intervention, but when an adult novice was playing, he/she was helped now and again by the child expert.

-Telling novices that "I have already mastered 2 and 3 times table by heart", as a way of motivating them to enjoy the game.

-In most cases child expert assisted child novices by giving instructions verbally i.e. telling them what to do, but assisted adult novice by playing on their behalf.

-Used collaboration to figure out answers to questions that a child novice asked and for which they had no immediate answers. Adult novice did not ask questions which the child expert could not answer.

Adult Expert

-The adult expert began by asking the novice if they knew anything about the game. Then explained what the software was all about, before giving the instructions for the game.

-Explained how the game was played, before demonstrating it practically.

-Whilst demonstrating she asked questions to the novices as a way of checking whether they understood these demonstrations.

-Had some instances in the game that they had forgotten even though they are experts. This is seen by their failure to answer some questions asked by the Novices e.g.

What is the use of the red and yellow bars?

What are the two grey buttons for?

-Unlike child expert who asked the novice player to play only when they felt they were ready, adult expert just told the novices to start playing after their demonstrations.

-Told child novices to figure out on their own if they asked questions for which the adult expert had no answers to.

Times Attack (How Novices learn)

Child Novices

-Interrupted with lots of questions when child expert was demonstrating, but hardly asked any questions when the demonstrator was an adult expert.

-Paid attention whilst being taught or whilst demonstrations were going on.

-Learnt more independently than adults, rarely asking for assistance during game play.

-Experimented with different game moves to find out what would happen if they did something new.

-At the start of the game, child novices repeated the purpose of keys used in the game to reinforce understanding, e.g.

"W" Walk forward

"S" Walk backwards

“B” Move to the right
“A” Move to the left
Spacebar is jump
-At first they moved the avatar using both hands on the keyboard, but as time went by left hand was on the keyboard and the right on the mouse.
-After the checkpoint was reached, they would grab the key by running into it. Then a door would be opened. Little cards would appear on the door that represented the multiplication problem they were learning. These would instantly jump off the door and turn into creatures. The novice would collect enough creatures to solve the problem, and then throw them back at the door by pressing the left mouse button.
-It was not easy to do it at first, but after one round when they had figured out how to do it they did it well.
-Once they had ‘built’ the answer the second time, they were able to type the answer in.
-A few of them who had asked what the bars on the top of the screen stood for were able to observe a small display at the top of the screen that tracked how many balls they needed to collect and throw.
-After building and solving the answer an Ogre would come out to make sure they remembered the answer.
-They would defeat the Ogre, by getting the multiplication tables then the Ogre would spit out another key that would let the novice open the next door. They would then meet progressively more challenging creatures that would teach, evaluate and reinforce all the numbers.
-Though they did not require a lot of help from the experts, they did ask questions here and there whenever they were confronted by something they did not understand.

Adult Novice
-Confirmed understanding by repetition or echoing the expert’s words.
-Paid very close attention to the demonstrations and seemed to ask more questions (than children) during and after demonstrations.
-Used body language (e.g. gesticulations) to emphasize something which they could not express well in words.
-With the help of the expert repeated the purpose of each of the keys used in the game.
-Asked for help the moment the game started, so the experts were helping them throughout the game.
-Started by moving the avatar with a bit of a struggle e.g. “This creature is refusing to move”.
-Managed with the help of the expert to move the avatar.
-Whilst playing the novice was talking to himself and even screaming when he failed to do what he wanted to do.
-It took him time to find the right door and was about to give up.
-With a bit of encouragement from the expert he continued playing.
-Finally reached the door and caught the snails, but was slow at giving answers for the multiplication tables.
-Kept asking for help from the expert.
-As time went by the novice was now enjoying the game.

Timez Attack (Difference in reactions/emotions to interface elements)

Child Expert
-No signs of nervousness by the child experts were shown at the beginning of the demonstration to a child novice, but were shown when they taught an adult novice.
-Appeared to be more relaxed when teaching a child novice than when teaching an adult novice.

Child Novice
-A bit shy at first, but relaxed soon after the expert started demonstrating the game.
-They showed various emotions e.g.

Laughing with satisfaction after completing a task (victory laugh).

Laughing at oneself when they had made a mistake (self-deprecating laugh).
Enjoyed the movement of walls in the game (Table below gives more information regarding emotions).

Adult Expert
-Enjoyed playing the game as they wanted to continue playing when their time was up.
-Sometimes got carried away and forgot to give the novice a chance to play.

Adult Novice
-Felt very relieved when they reached a goal. Showed by laughing, (Victory laugh) and sighing.
-Laughed at themselves when they failed to do what was required of them (self-deprecating laugh).
-Very excited on reaching a checkpoint (shown by mannerisms).
-Gave up easily when they could not play the game, e.g. 'I give up'!
-They were frustrated by the continuous appearance of the creatures (e.g. snails) which they thought they had already destroyed.

Times Attack (Self Tutoring)

Child Novice:
What they did at first:
The first thing done by child novices was to click the Play button. Eye tracking results also show that child novices' longer fixations were on the Play button.

The videos observed also show that the child novices first clicked the Play button, after longer fixations were on play.

How they proceeded:
Later in the game the novices entered a part of the game where a lot of movement was happening on the screen (the creatures running around to be collected). Child novices paid little attention to the instructions. This showed that children were more confident to learn through trial-and-error.

Adult Novice:
What they did at first:
Adult novices clicked on the Tutorial button first.

How they proceeded:
When playing the game, results from eye tracking show that the first thing adult novices did was to read instructions given at the bottom of the game. The adults had the most fixations on the instructions during the first 20 seconds of the game, see example figure below.

What the child novices found difficult while self-tutoring:
-Child novices had difficulty in collecting the creatures at first, but this was just for a short time.
-Most of them did not read instructions at the bottom of the game before they started playing the game. The reason why child novices did not read the instructions might have been the unfavourable placement of the instructions. The instructions were placed at the bottom of the screen and were written in very small font. It would have been better if the instructions had been written on top and in a bigger, more visible font.

What the child novices found easy while self-tutoring:
-They found that doing times tables was the easiest part of playing the game. This might have been as a result of time limitation. Participants only concentrated on the first times tables, 2 and 3, which were easy. The positive thing coming out of this research is that the children all enjoyed learning their times table through game play.
-Child novices had good control of both hands. They quickly found it easy to simultaneously manipulate the mouse using one hand and the keyboard using the other.

Reactions (Emotions) to interface elements:
-Laughing at the monster when they brought it down.
-Words like Oh no! or Aaaa! were heard when thinking that they have collected all the creatures and another one just appears.

What the adult novices found to be difficult while self-tutoring:
-Found collecting the creatures as the most difficult part of playing the game.
-Found hand coordination on the mouse and keyboard difficult.
-Reading game playing instructions many times.
-Slow to figure out the next step even after reading the instructions.

What the adult novices found to be easy while self-tutoring:
-Found it easy to do the times tables because they only did 2 and 3 times table. One adult who attempted the 5th times table struggled to get all answers correct.

Reactions (Emotions) to interface elements:
-Adults showed more emotions than children:
-Laughing at the Ogre when it fell.
-Singing in satisfaction on managing to collect all the creatures.
-Umm when figuring what to do.
-Oh good grief, when more creatures appeared.
-Uwee when he knows what to do.
-Ola and Ahi when defeating the creatures.
-Got you! Hey! Oh my! Good boy! Ah! Die! Feel the pain!, when killing the Ogre.
-Ah come on when multiplication tables appear again.
-Bingo! At last!

Table B.1 below shows the summary of the things both the novice children and adults struggled with, did not struggle with; had fun doing and different emotions shown whilst playing the game:

Table B.1 Some observations of differences between adults and children

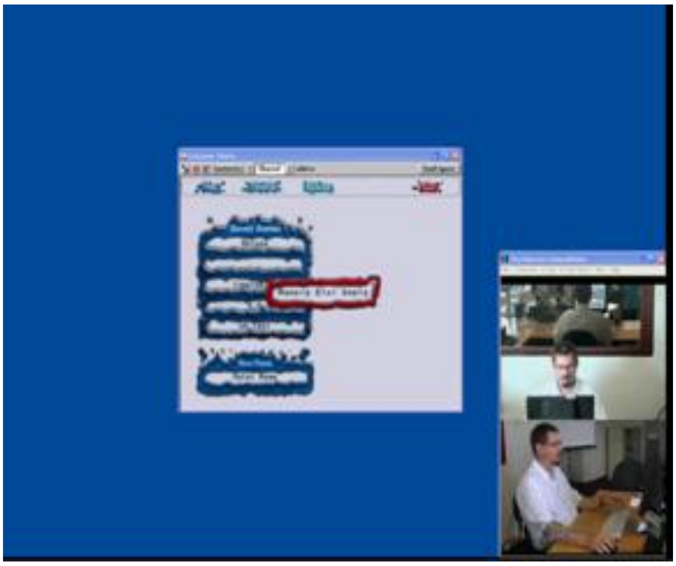
	Children Novices		**Adult Novices**
1.	**Aspects of software they struggled with:**	**1.**	**Aspects of software they struggled with:**
√	Using both hands on the keyboard to type answers of multiplication tables.	√√√√	Struggled to coordinate both hands. Seen using two hands to type instead of left hand on the keyboard and right hand on the mouse.
√	Used the wrong hand to click.	√√√√ √√	Struggled to catch/collect the creatures/snails.
√√	Struggled a bit to use the mouse.	√√	Struggled to find the key to open the next door.

√√√	Struggled a bit to catch the snails/creatures (slow on catching snails).	√√√	Walk using a mouse (Mouse navigation).
√		√√√√	Turning the mouse like a steering wheel.
√	Failing to move the avatar to the right place.	√√√√	Difficulty moving the mouse.
	Failing to find the right door.	√√√	Keep on clicking at the wrong door.
		√√√√	Struggling/Failing to find the right door.
		√√	Could not figure out what to do on your own/ slow to figure out the next step.
		√√√	Keeping moving the keyboard
2.	**Aspects they had no problem with (easy)**	**2.**	**Aspects they had no problem with (easy)**
√√	To turn using a mouse and walk with arrow keys.	√√	Turn with a mouse and walk with the key.
√√√√√	Doing times tables.	√√√	Multiplying numbers.
√√√√	Moving the mouse, when moving the avatar.		
√√√	Good control of hand and mouse.		
3.	**What aspects were fun?**	**3.**	**What aspects were fun?**
√√	Getting rid of the ogre	√√√	Getting rid of the ogre.
√√√	Pressing button 'W' and the avatar jumping.		
√√√√	Movement of walls in the game.		
4.	**Reactions (Emotions) to interface elements**	**4.**	**Reactions (Emotions) to interface elements**
√	Oops when failing to do something and saying : "l feel stupid"	√√	Holding chick when failing to figure out what to do next.
√√	Putting hand on the mouth (shame) when the avatar fell into a ditch.	√√	UHM! When managing to open door.
√	Playing the game with a serious looking face.	√	Playing the game with a serious looking face.
√√√	Umm!	√	Used swear words "Nia fuck"!
√√√√√	Laughing	√√	Scratching one's head and arms.
√√	Oh no!	√	Raise hands in the air, rejoicing after destroying the Ogre.
√√	Aaaa!	√√√√	Laugh throughout the game/ Oh! Oh! Oh! Mmm! When falling 3 times in a row.
		√√√	Talking to oneself.
		√ √ √√ √√	Sjoe! Ok what now? Oh gosh- how now. Oooooooohmmm! Oh finally.

Timez Attack (Software-related problems)

There were problems with the interface at the start of the game when one wanted to save the game in one's own name. All novices struggled to enter names in-order to start playing the game. Each time they clicked on 'new game' and 'enter name', a message "Memory slot full" popped up.

And when deleting an existing name or saved name to put theirs a message "Memory slot empty" appeared.



This usability problem confused the players. Instruction on how to go about this is not given. The recommendation is that sufficient memory is required and instructions on how to save should be given, once the message appeared.

The other problem was when playing the game, at the initial stages of the game a congratulatory message, "Congratulations for reaching the checkpoint" popped up. This was a surprise to both the experts and the novices because they could not figure out which check point was being referred to. The message popped up when they had not really done much.

Again more information should be given regarding checkpoints.

StoryBook Weaver Deluxe

StoryBook Weaver Deluxe is the second educational game software which was used during experiments. The aim of the software game is to help children do creative writing and express their vivid imaginations in English.

StoryBook Weaver (How the Expert taught the Novice)

Child Experts
-Child experts first demonstrated how the game was played before asking the child novices to play the game too.
-On very rare occasions some of the experts would ask questions and solicit the preferences of the novices, e.g.
Which animal do you want me to take?
Which background do you prefer?
-Child experts sometimes also asked the child novices to participate in the creation of the story, e.g. Choose the object you like and click on the + button

Adult Expert
-She first read the tutorials given and also, together with novices, went through the game demonstrations.
-Demonstrated the game whilst novices watched.
-She gave the novices chances to play whilst she watched.

StoryBook Weaver (How novices learn)

Child novices
-Interrupted with lots of questions when child expert was demonstrating the game, but hardly asked any questions when the demonstrator was an adult expert.
-Paid attention whilst being taught or whilst demonstrations went on.

How they played the game
-Child novices began with the Title Page where they named their stories, typed in the author and even added decorative borders by choosing the frames of their choices.
-A few of them wrote comments or dedications on the comment section.
-On the next page they chose backgrounds for their story pages. There were many backgrounds to choose from therefore they found it difficult to make a choice.
-After backgrounds they then chose objects they wanted for their stories, some chose animals, others cars and others spaceships.
-They put sound to their objects and record their voices.
-They edited their pictures, by changing colour, making their pictures small or big.
-They then wrote stories which were in connection with their pictures.
-They then saved all their work.

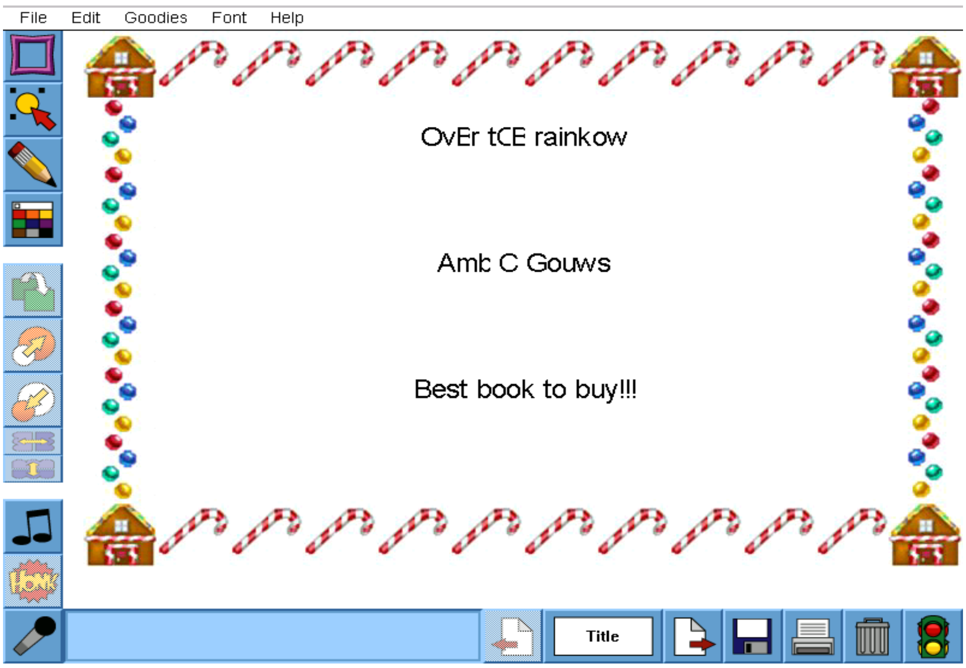
Aspects of software interface they struggled with:
-They struggled to reduce the sizes of the objects, e.g. the unicorn.
-They failed to get the drawing they really wanted e.g. a spaceship.

-They also struggled to put in place the other objects they wanted.
-Hitting one's head when struggling and failing to check the spelling.
-When trying adding more features to the objects and failing.
-It was difficult to check spelling, because one had to keep pressing the Menu bar to be able to correct spellings. The game does not have the facility to show that a wrong spelling has been written or just to correct it like Word.
-Had lots of choices to choose from on background and objects, sometimes they had difficulty choosing what they really wanted.

-Two of the participants, when frustrated had a tendency to concentrate on changing pictures and sound.
-Experts tended to chip in and check what was wrong, and help.
-Aspects of the software they struggled with were:

- when trying to check spellings, the button to click for help could not be used.
- when trying to change the original colour of the objects they had chosen to put their own, one would struggle to change. The colour would be changed on smaller portions each time.

-The novice children had problems with the user interface once they had launched the application. They took time to get used to the idea that when you want to apply a given selection option you had to click **(X)** not the **(√)**. For them, a cross meant **NO**, and they would have preferred a tick, to mean **YES**.
-The buttons were too many and as they beginners it was difficult to master what each one stood for. It would be better to have a pop up message which gets displayed next to button stating what they stand for. The software showed playing instructions at the bottom of the game, which could not easily be noticed.
-Some of the novices were not confident with writing a comment.
-Sometimes the letters which the participants had written on the title page were distorted on going back to view them. This brought frustration to the participants, as they were not able to correct the distorted words. It will be necessary to revisit the viewing functionality (view picture below).



What the novice children had fun doing

-Animation and sound effects were positive design elements for novice children. They often created a good first impression that encouraged the novice to want to do more.
-Novices were willing to explore more and to find clickable areas or simply to enjoy the sound effects that different screen elements played.
-Had a lot of choices on backgrounds and objects to choose from.
-Novice children enjoyed creating their own pictures with the help of the many foregrounds and backgrounds provided. They liked the pictures and other simulated environments that were given (view pictures below).

Storybook Weaver (Reactions to interface elements)
-There were smiles and laughter after accomplishing something, for example, finding the animals to include in the story and being able to add trees grass and many other objects in their stories.
-Sighs, like 'Oh no', Eish', Oh my God' were heard whenever the novices failed to achieve a goal e.g. when they could not further reduce the sizes of the objects, e.g. the unicorn and when they failed to get the drawing they really wanted for a spaceship and also struggled to put in place the other objects they wanted.
-Dancing to the sound which they had chosen to go along with the objects chosen.
-Jumping with joy after recording one's voice and hearing it come out of the speaker.
-Positive body engagements were shown, e.g., clapping hands on being satisfied by themselves, walking around with confidence and jumping with joy when they completed putting together pictures of their stories. An example is shown below:

-Expressions like 'My word', 'Yes Yes' were used quite a lot when they had managed to create stories.

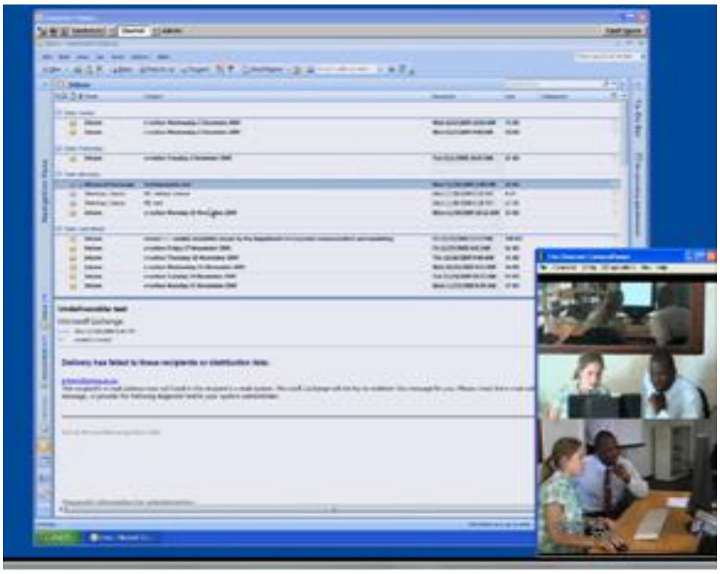
Storybook Weaver (Software problems)
-The screen resolution was low. They could not edit on one window when another one was open. They had to close the one on top to be able to edit the bottom window.
-They could not delete the music if they no longer like it. They could only replace it with another.
-Navigation was also inconsistent. The same options were referred to in different ways, again causing a lot of frustration on the part of children, for example an **X** would in the first instance be used to 'apply' if one wants to place a background on one's story and later on it is used to mean 'close' the page you are working on. It would be better that it be used for one purpose in the software.
-The demonstrations given at the beginning, to show how the software works, were too fast for novices who were beginners. The demonstrations were supposed be slow in order to be understood by the novices.

Microsoft Outlook

Microsoft Outlook software application was used in the experiment. Email is a way of sending messages between people over the internet.

Microsoft Outlook (How the Expert taught the Novice)

Child Experts
-Showed examples of finished products before demonstrations, e.g. emails received, those that were send and those that have not been read.



-Demonstrated how to write and send an email.
-Explained what the menus on the page were for.
-Asked the novices if they are happy and satisfied with the demonstrations.
-Asked the novices to create their own emails.

Adult Experts
-Started by asking questions to the novice e.g. Have you used any email before?
-Then gave brief explanations on what an email was.
-Gave examples of similar things to email e.g. "An email carries the same principle as sending an sms on a cell phone, or writing and posting a letter via post office. The only difference is that this is done electronically".
-Showed examples of finished products before demonstrations, e.g. emails received, those that were send and those that have not been read.
-Adults experts gave a lot of information here because they are well versed with the software than they did with children software.

Microsoft Outlook (How the novices learnt)

Child novices
-Asked questions to the experts pertaining to what they were doing.
-Follow what they have been taught.

Adult novices
-The experts assisted the novices all the way.

Microsoft PowerPoint

Powerpoint (How the Experts taught the Novice)

Child experts
-They went straight into the program and explained how to do a PowerPoint presentation.
-The child expert demonstrated what was to be done first.
-Involved the novices in all the steps, in other words, worked together with novices from the beginning to the end.

Adult experts
-First displayed a completed slide to the novice.
-Then demonstrated how to prepare a presentation.
-Worked together with the novices from the beginning to end.

Powerpoint (How the adult novices learnt)
-Asked questions to the experts pertaining to what they were doing from the time the expert started demonstrating until the end.
-When it was their turn to do what had been demonstrated they asked for help every time.

Table B.2 below shows the summary of the things both the novice children and adults struggled with, did not struggle with; had fun doing and different emotions shown whilst learning how to use PowerPoint software:

Table B.2 Some observations of differences between adults and children

	Child Novice		**Adult Novice**
	Aspects of software they struggled with:		**Aspects of software they struggled with:**
		√√	Challenging in the sense that one has to watch all the movements and then do it.
√	Struggled to remember all the steps to follow when preparing PowerPoint presentation.	√√	Struggled to remember all the steps to follow when preparing PowerPoint presentation.
		√√	Struggling to understand the logic of the broader window.
√√	Struggling to make a choice on the many designs given.	√√	Struggling to make a choice on the many designs given.
	Aspects they had no problem with (easy):		**Aspects they had no problem with (easy):**
√	Formatting	√√	Formatting
√	Doing the slide shows	√√	Doing the slide shows
√	Custom Animation	√√	Custom Animation
	Aspects they had fun doing:		**Aspects they had fun doing:**
√√	Custom animation	√√	Custom animation
√√	Slide shows	√√	Slide shows
√√	Slide transitions	√	Slide transitions
√√	Clip Art	√	Clip Art
	Reactions (Emotions) to interface elements:		**Reactions (Emotions) to interface elements:**
√√	Oh!!	√√	Laughing at custom animation
√	Good Lord	√√	OK this is lovely!
√	Ah!!	√	Good!!!
√	OK	√	Aaaa!!
		√√	Oh! I see
		√√	Oh! OK. Alright
		√√	Ok! Aha Aha!

Appendix I: Publications

1. Pretorius, M., Gelderblom, H. & Chimbo, B. 2010. *Using Eye-Tracking to compare how adults and children learn to use an unfamiliar computer game*. In Proceedings of SAICSIT 2010, Bela Bela, South Africa: ACM Press.

2. *A Comparative analysis of the meaning of 'Learnability' for child and adult users* by Chimbo, B., Gelderblom, H. and De Villiers, M.R. Accepted at the IADIS International Conference Interfaces and Human Computer Interaction 2011 Rome, Italy 24 - 26 July.

{Copies of these papers follow on the next page.}