Determining the Usability of Pedagogical Interface Agents in the Context of Adult Computer Literacy Training: A South African Perspective

By

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Submitted in fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR

In the Faculty of Natural and Agricultural Sciences

Department of Computer Science and Informatics

University of the Free State

Bloemfontein

South Africa

July 2016

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It Always Seems Impossible Until it is Done ~Nelson Mandela ~

Acknowledgements

- I glorify GOD Almighty for giving me grace, strength, courage and wisdom to carry out this work.
- I would like to express my deepest appreciation to my promotors, Dr Lizette de Wet and Prof Robert Schall, for the privilege of working under your supervision. Without your unique perspectives, invaluable assistance, guidance and positive feedback this thesis would not have been possible.
- I would like to thank the Telkom Centre of Excellence (CoE) at the Department of Computer Science and Informatics, UFS for funding this research.
- Thanks to the staff of the Information Technology Department at the Central University of Technology (CUT), Free State for all the support, especially Mr C Wessels for providing the computers that were used to carry out this research.
- Special appreciation and many thanks go to Mr P Potgieter who developed SMOS and also the adult learners from MUCPP for their willingness to participate in this research.
- To my friend, the late O Platjiee, thank you very much for pushing and encouraging me to take up this PhD challenge.
- I would like to thank Mr P Havel, Mr L Keyise, Prof J Chadwick, Prof HN Muyingi, and Prof A Terzoli for laying a solid foundation at the start of my academic journey, which has taken me this far.
- Thanks to Mrs S Opperman for taking time to text edit this thesis.
- To my father (the late Mr G Mabanza) and my mother (Mrs Y Mabanza), brothers (Godet, Moni, the late Zuka, and the late Jonas) and sisters (Theresse, Niclette and Sarah), thanks for always believing in me. You have made me strive to be a better person.
- To my beautiful wife, my sweetheart Mrs KS Mabanza, thanks for your love and support during this PhD journey.
- Very special thanks to my cousin Dr M Taluanga and his family for all they have done for me to get this far. Also thanks to Prof Muyima and Dr Tshikala.
- Last but far not least, a hearty thanks to my uncle (N Mundundu), my comrades (B Ingila, G Muriithi, M Masitenyane and T Nkalai) and my cousins (Dr A Muyingi, R Bubu, M Bubu, V Matondo, and P Nzwanga) for their underlying support and encouragement.

Dedication

To my father, the late Mr GNM Mabanza, who spent all his life teaching me how to make history. I wish you were still alive to witness this moment. May your Soul rest in peace, your legacy will forever remain alive.

To my mother, Mrs MY Mabanza for her infinite affection, and very positive thoughts about my life.

To my wife, Mrs KS Mabanza for her support, patience, encouragement endless love and understanding.

Declaration

I,……, declare that the Doctoral Degree research thesis that I herewith submit for the Doctoral Degree qualification in **Computer Science Information Systems** at the University of the Free State is my independent work, and I have not previously submitted it for a qualification at another institution of higher education. I further declare that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

I,……, hereby declare that I am aware that the copyright is vested in the University of the Free State.

I,……., hereby declare that all royalties as regards intellectual property that was developed during the course of/or in connection with the study at the University of the Free State, will accrue to the University.

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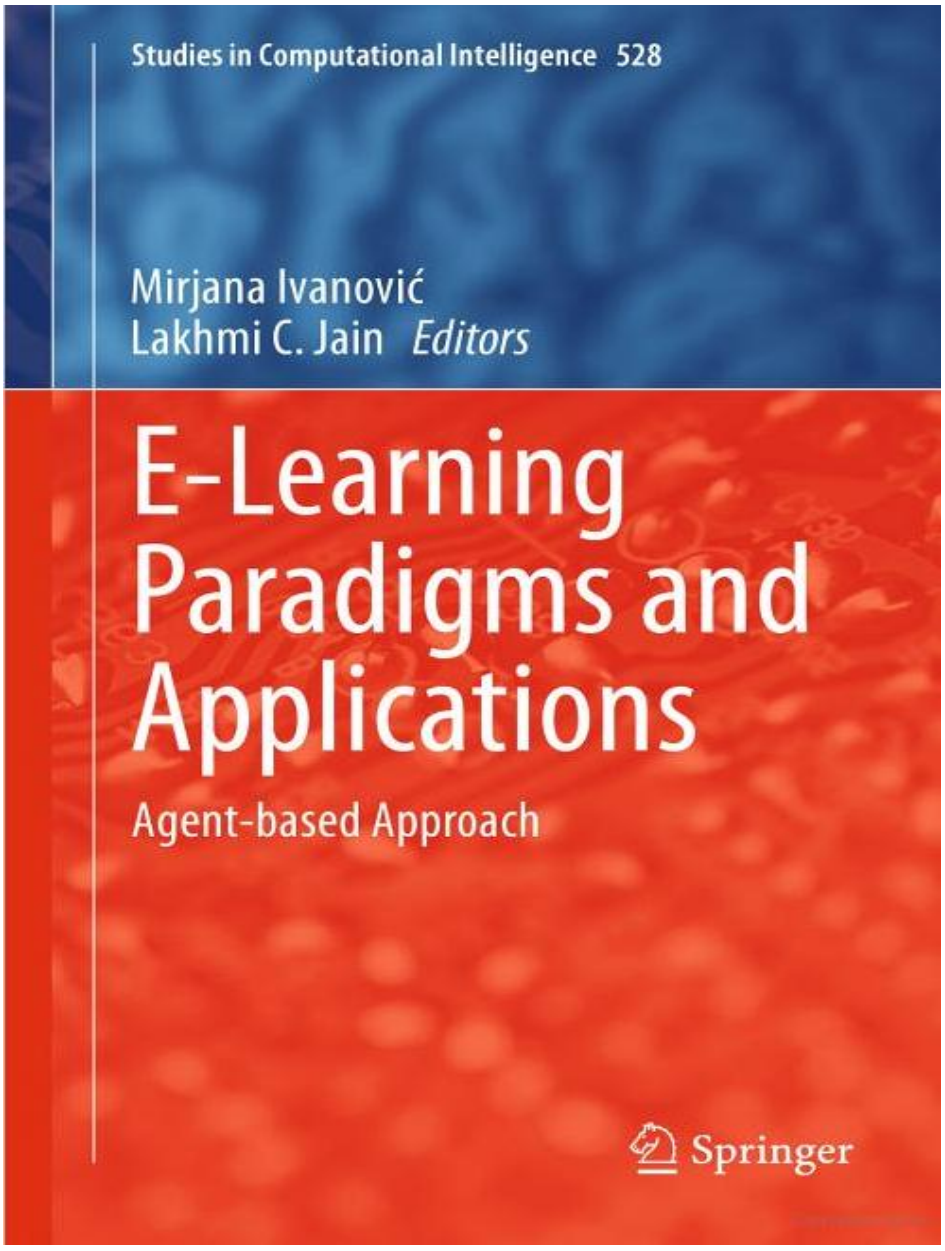
N. Mabanza **Date**

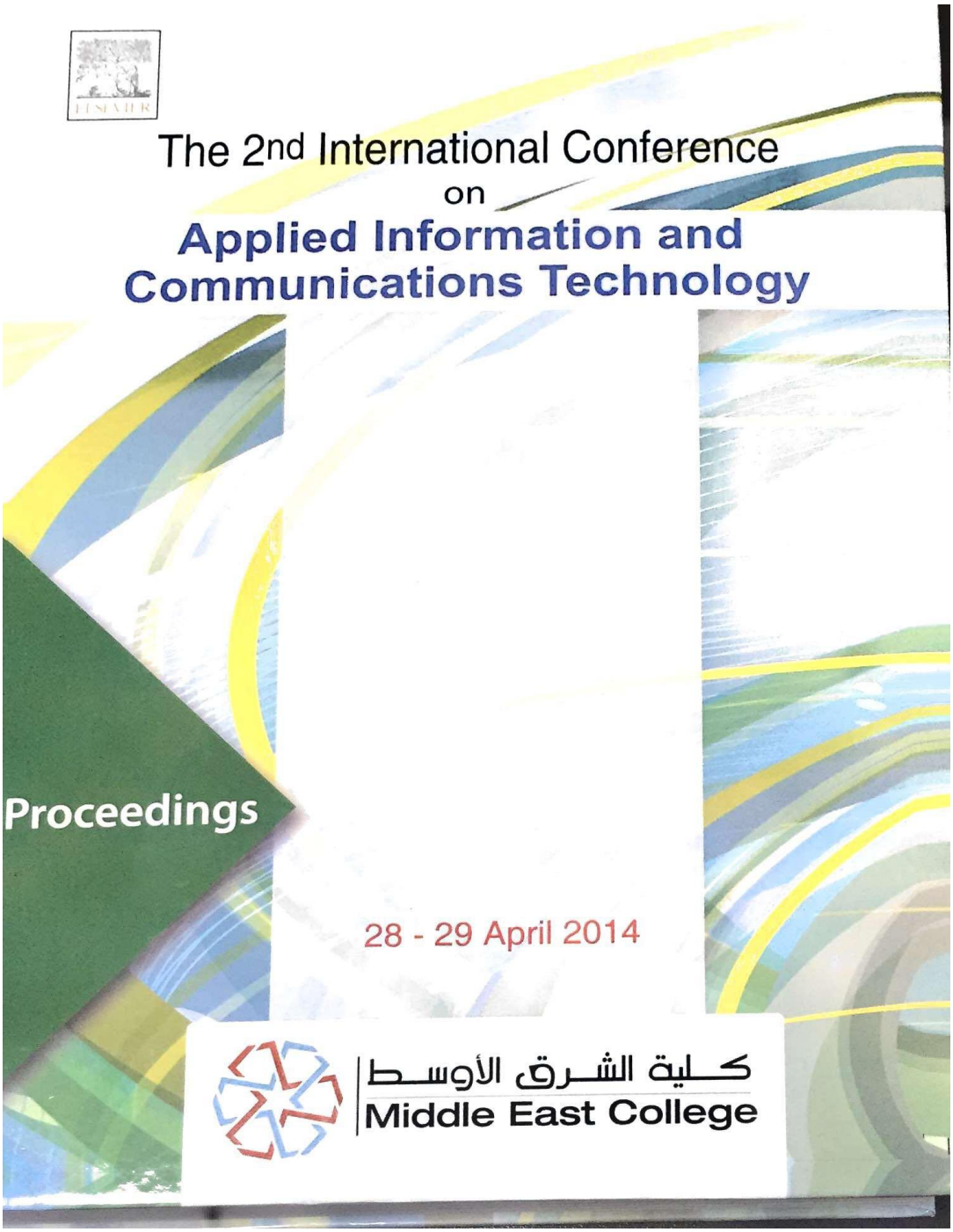
Preface

Extracts of this study have been published as a chapter in a book, and it has been also presented at an international conference. Because of the length of the book chapter (37 pages) only the abstract and keywords are presented in Appendix O-1. The conference proceedings are included in Appendix O-2.

1. Mabanza, N. & De Wet, L. (2014a) 'Determining the usability effect of pedagogical interface agents on adult computer literacy training'. In: Ivanovic´, M. and Jain, L. C. eds. *E-Learning Paradigms and Applications, Studies in Computational Intelligence,* 528. Berlin: Springer-Verlag, pp. 145-182.



2. Mabanza, N. & De Wet, L. (2014b) 'Adult learner interaction with pedagogical interface agents during computer literacy training', *Proceedings of the 2nd International Conference on Applied Information and Communications Technology (ICAICT2014).* Middle East College Muscat, 28-29 April. New Delhi: Elsevier, pp. 327-332.



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List of Abbreviations and Acronyms

ABET:	Adult Basic Education and Training
Adele:	Agent for Distributed Learning Environment
AI:	Artificial Intelligent
BT Labs:	British Telecom Laboratories
CARTE:	Centre for Advanced Research in Technology for Education
CUT:	Central University of Technology
df:	Degree of freedom
DFKI:	Deutsches Forschungszentrum für Kunstiche Intelligenz
EU:	European Union
EXA:	Expert Agent
Fear-Not:	Fun with Emphatic Agents Reaching Novel Outcomes in Teaching
GDP:	Gross Domestic Product
HCI:	Human-Computer Interaction
ISO:	International Organisation for Standardisation
ISO/IEC:	International Organisation for Standardisation/International Electrotechnical Commission
max:	Maximum
MEA	Mentor Agent
min:	Minimum
MUCPP:	Mangaung-University of the Free State Community Partnership Programme
OLCPA:	Online Learning Cartoon Pedagogical Agents
OLHRPA:	Online Learning Highly Realistic Pedagogical Agent
OLMRPA:	Online Learning Moderately Realistic Pedagogical Agent
PCs:	Personal Computers
PIAs:	Pedagogical Interface Agents
QLFS:	Quarterly Labour Force Survey
SA:	South Africa
SAS:	Statistical Analysis System
sd:	Standard deviation

SMMEs:	Small, Medium and Micro-sized Enterprises
SMOS:	Simulated Microsoft Office Word System
SPSS:	Statistical Package for the Social Science
SQL:	Structured Query Language
Steve:	Soar Training Expert for Virtual Environments
UEMs:	Usability Evaluation Methods
VICTEC:	Virtual Information Computer Technology with Empathic Characters
WHO:	World Health Organisation

Chapter 1: Introduction

1.1 Introduction

In the digital age, the term *literacy* does not only refer to the ability to read and write, but also to the acquisition of a range of competencies to effectively engage and function within a technological dependent society. Computer literacy is one example of these competencies. The Collins Dictionary (2013) defines computer literacy as the ability of someone to have enough skill and knowledge to use a computer. Nowadays, computer literacy is viewed as one of the major requirements to enter the job market as various careers require the use of computers as part of everyday tasks. It is, therefore, vitally important to be computer literate. However, the acquisition of computer literacy skills among the adult population is a challenge in developing 3rd world countries, since there is still a large portion of the adult population who has never interacted with a computer, or lives in technological ignorance.

Different causes contribute to technological ignorance among populations in developing 3rd world countries. Illiteracy among adults can be viewed as one of the main causes. A study by Dagatan (2012) identified economic conditions, poor implementation of educational programmes, preference to work over education, rate of emigration, individual disability, lack of funds, cultural influences, geographical factors, mind-set about education, and population growth as the ten major causes of illiteracy in the world. Another possible cause is that the current computer training approaches, such as conventional training, in which the training is conducted by a skilled human instructor, or e-learning, which involves the use of the Internet to facilitate training (e.g. The Siyakhula Living Lab), could be challenging for individuals (especially adults) who have never been exposed to a computer, and it might sometimes pose an intellectual challenge to them due to their unfamiliarity with technology. The shortage of qualified human computer instructors in some developing 3rd world countries could also be viewed as another possible cause.

Taking into account the aforementioned, it becomes clear that there is a great need to find ways to support individuals with little or no technological background, in developing 3rd world countries, and to integrate modern technology into their social and work activities.

The current study is viewed as an attempt towards finding effective ways for addressing the computer literacy problem faced by the majority of the population in developing 3rd world countries (Mabanza and De Wet, 2014a; Mabanza and De Wet, 2014b). The scope of this research study will include three main areas, namely agents, adult computer literacy training and usability. Each of these main areas will now be discussed in detail. The remainder of this chapter is structured as shown in Figure 1.1.

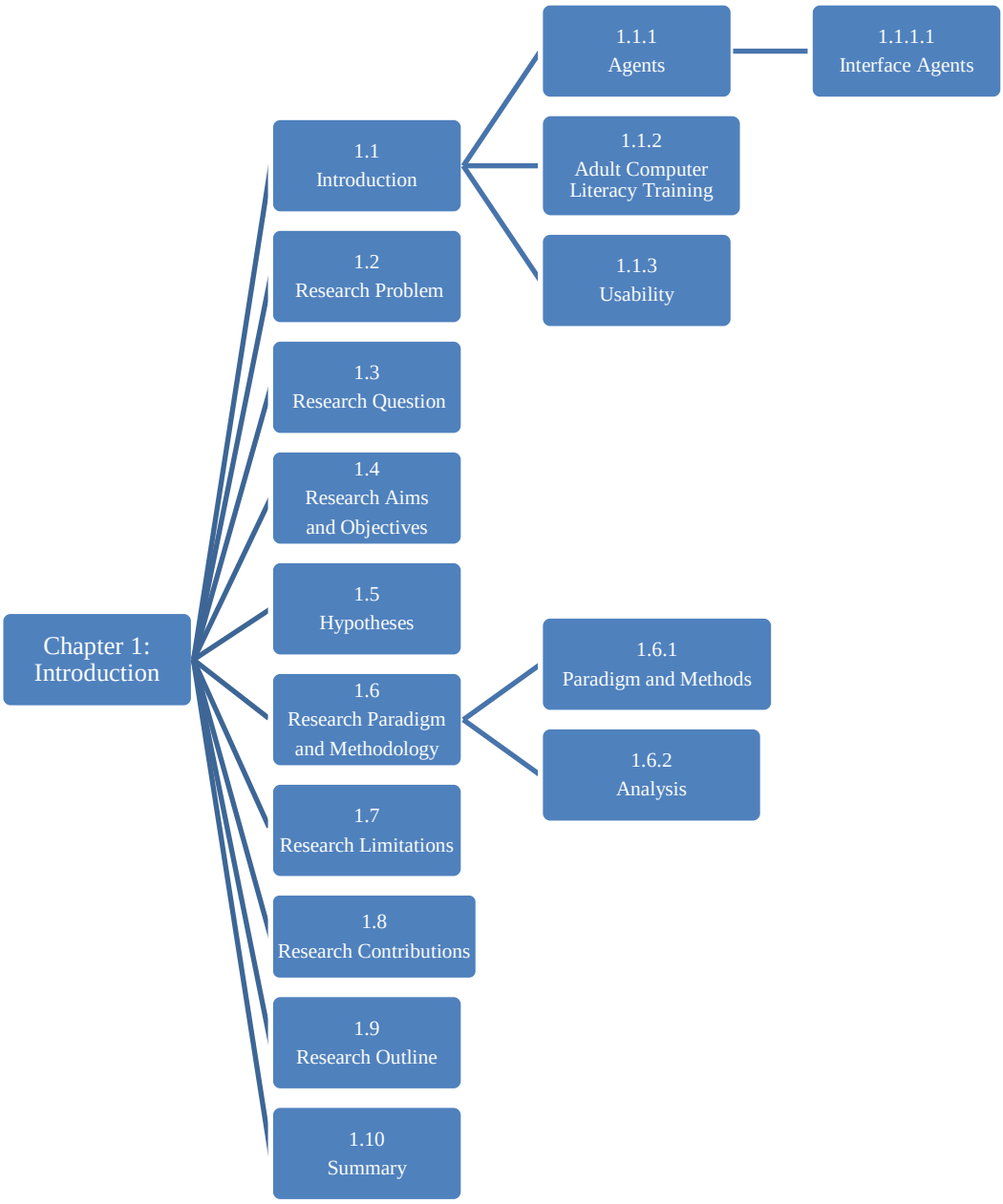


Figure 1.1: Schematic Representation of Chapter 1

1.1.1 Agents

There is no consensus on the definition of the term *agents* in a computer science context (Giraffa and Viccari, 1998; Rudowsky, 2004; Shonali, 2005). Yet, existing literature reveals that there is agreement among many researchers about some characteristics that agents should exhibit. For example, Etzioni and Weld (1994), Giraffa and Viccari (1998), Meenakshi, Sehgal and Anand (2010), as well as Shonali (2005) pointed out that an agent must exhibit some (but possibly not all) of the following desirable properties: reactive, autonomous, goal driven, communicative, pro-active, adaptive/learning, persistent, benevolent, deliberative, temporally continuous, mobile, flexible and representing a character. As a result, various agent definitions have been suggested (Chapter 2). Hence, the definition of agent chosen for this study combines aspects of the proposed definitions by Gavalas, Tsekouras and Anagnostopoulos (2009), Koch and Rahwan (2004), and the Merriam-Webster Dictionary (2013) to form a single definition emphasising selected agent characteristics that are considered to be useful in this case. The term *agent* will, therefore, be defined as follows:

An agent is an autonomous computer system with a precise goal-oriented task, capable of acting on behalf of a human user to automate computer related tasks in a communicable way to meet the user's needs.

The lack of agreement in the research community about what constitutes the essential properties of an agent has led to the existence of many possible proposed agent classification schemes (Chapter 2). Following in-depth literature renowned for these schemes, the author concluded that the agent classification scheme proposed by researchers from the British Telecom Laboratories (BT Labs) is the most accepted (i.e. most referred to) in the research community. This proposed agent classification scheme is based on crucial properties being emphasised in a particular agent. BT researchers identified four properties, namely mobility, behavioural model, primary attributes and roles that can be used to classify an agent (Meenakshi *et al*., 2010; Nwana, 1996; Moraitakis, 1997). Nwana (1996), a researcher at BT Labs, referred to these four properties as the four dimensions of agent topology. Mobility refers to the capability of an agent to move around a network. The behavioural model characteristic of an agent refers to the agent's internal states, including the manner in which an agent models its environment. Primary attributes refer to ideal primary characteristics that

an agent should display. Roles refer to the specific character assigned to the agent (Chapter 2).

Additional to the four dimensions of agent topology discussed above, it is also possible to identify other properties of agents. These are referred to as agents' secondary attributes. Secondary attributes include additional characteristics that an agent can display, e.g. versatility, benevolence, competitiveness and veracity (Meenakshi *et al*., 2010; Nwana, 1996; Shonali, 2005).

The four dimensions of agent topology proposed by BT researchers (Nwana, 1996) have given way to seven different types of agents, namely collaborative agents, interface agents, mobile agents, information/Internet agents, reactive agents, hybrid agents and smart agents (Meenakshi *et al*., 2010; Moreno, 2010; Nwana, 1996; Shonali, 2005)**.**

Due to the lack of consensus on the definition of agenthood, BT researchers also acknowledged that their proposed agent classification scheme is bound to be debatable. As a result, they are also in agreement that their proposed classification is not an exact separation.

In this research study, the researcher used the agent classification scheme of the BT researchers. Among the seven types of agents proposed, the focus of this study will be on interface agents.

1.1.1.1 Interface Agents

There are many ways in which the term *interface agent* can be defined. This mostly depends on the kind of properties that are deemed necessary to be exhibited by a particular interface agent (Chapter 2).

The definition of *interface agent* selected for the purpose of this current study combines the definitions of Lincicum (2003) and Serenko (2006) into a single definition. Hence, an interface agent will be defined as follows:

An interface agent is a reactive, collaborative and autonomous visual character enacted by a computer that communicates directly with a user in a socially engaging manner, offering him/her assistance and advice in performing computer-based tasks.

Interface agents act as intermediaries between a user and computer-based tasks. Their main purpose is to ease the human-technology interaction, as well as to make the use of software a more enjoyable experience. Therefore, in order to achieve their purposes, interface agents are mostly given human traits or behaviour. The main reason for doing so is to produce an emotional response that creates a relationship between the user and the computer (Morgan, 2013). In order to make this emotional response appear natural the interaction with the user is done using natural language, through voice recognition, or via textual input and output.

Existing literature indicated that interface agents are used or implemented in different disciplines and application domains. These include e-Commerce, entertainment, medicine and education, to mention a few. The application of interface agents in education (referred to as educational agents) will be the core of this research study.

Educational Agents

An educational agent is a particular piece of educational software with human characteristics, which is autonomous, continuous, reactive, collaborative and communicative, and able to facilitate social learning (Lieberman and Selker, 2003; Serenko, 2006). Its main purpose is to assist a user in the completion of his/her tasks. Hence, in order to assist a user in a socially engaging manner, the human-like characteristics of an agent are frequently expressed in the following formats: textual, graphical, icons, voice, animation, multimedia, or virtual reality (Chou, Chan and Lin, 2003).

A number of different types of educational agents exist (Giraffa and Viccari, 1998; Chou *et al*., 2003). However, the well-known classification of agents provided by Chou *et al*. (2003) divided educational agents into two major categories, namely personal assistants and Pedagogical Interface Agents (PIAs). A personal assistant can perform as a teacher assistant or a learner assistant, while a PIA can perform as a tutor or a co-learner (Landowska, 2008). A tutor agent plays the role of an instructor, while a co-learner agent plays the role of a learning companion.

For the purpose of this research, the focus will be on PIAs playing the role of tutors.

Examples of Existing PIA Systems

Over the years, many PIA systems have been developed and used in various instructional fields. A few examples of these systems are shown in Table 1.1 below.

Table 1.1: Examples of Existing PIA Systems

Source	Agent	Purpose (instructional field)
Alpert, Singley and Fairweather (1999)	Algebrain Equation Solver	Mathematics
André, Müller and Rist (1996)	PPP Persona	Web Content
Aylett, Louchart, Dias, Paiva and Vala (2005)	Fear-Not	Educate Kids about Bullying Behaviour
Bertrand, Babu, Polgreen and Segre (2010)	Dr Evan	Hygiene Education
Conati and Maclaren (2009)	Prime Climb	Mathematics
Gilbert, Wilson and Gupta (2005)	Adam	Computer Programming
Graesser, Moreno and Marineau (2003)	Auto Tutor	Computer Literacy Topics
Herman the Bug (1998)	Herman the Bug	Botanical Anatomy
Johnson (2000)	Adele	Medical School Students
Lester, Voerman, Towns and Callaway (1997)	Cosmo	Computer Network
Sabot, Aini and Lew (2005)	Computer and Virus Educational Systems	Computer Virus
Steve in action (2000)	Steve	Naval Training
Suraweera and Mitrovic (1999)	Smart-egg	SQL Computer Programming
Theodoidou (2011)	Laura	Language

However, very little is known about the use of PIA systems in a word processor environment. Therefore, this study will seek to investigate the possibility of using a PIA system in a word processor environment. A simulated word processor system called the Simulated Microsoft Office Word System (SMOS) that incorporated 10 different kinds of PIAs, developed by Potgieter (2010), will be used in this study (Chapter 3).

Studies on PIAs

Most of the research done in the field of PIAs emphasised the different factors influencing the interaction between the users and the agents. Existing literature on PIAs revealed that those factors can be classified into three categories. These include agents' appearance, facial expressions and behaviours. Multiple studies performed on these three categories yielded positive results. These studies will be discussed in Chapter 2.

Similar to previous studies, this study also investigates a selection of the various factors affecting user-agent interactions, such as the agent's appearance, voice, movement, gender, etc. Unlike previous studies, the focus of this study, in terms of the population, will be on adult computer illiterate users with no formal post-school training, in the context of 3rd world countries.

1.1.2 Adult Computer Literacy Training

Adult computer literacy training refers to a training program conducted to assist adult learners in acquiring basic knowledge and skills to use computers to perform basic tasks (i.e. creating a document).

Nowadays, adult computer literacy training is usually conducted using approaches such as conventional training and e-learning. Often, these approaches pose intellectual challenges to computer illiterate adults because of factors such as lack of self-esteem and confidence, which are mostly due to the lack of basic education at a younger age, as well as their unfamiliarity with technology. Another challenge for these trainees is that during training it might be practically impossible for the skilled human instructor to cater for all individual training needs. Therefore, to avoid marginalising these individuals, education providers need to find innovative solutions (Githens, 2007). Wonisch and Cooper (2002) suggested that the educational multimedia and computer-based training industries look towards PIAs as a promising solution to the challenges of modern educational environments. As it is, PIAs can be designed to perform a human instructional role as they can communicate with the learners in natural language (Landowska, 2008).

The fundamental underpinning of this research undertaking with regard to the above, is the view that the incorporation of PIAs into adult computer literacy training may allow the overcoming of many problems faced by adult computer illiterates during their training, and may improve their computer performance.

In order to determine the best approach, best techniques and best aesthetics in software applications, evaluation to investigate usability is a necessity. In this study, the incorporation of PIAs during computer literacy training needed to be evaluated by means of usability evaluation.

1.1.3 Usability

In the context of this study, the researcher adopted the ISO 9241-11 (1998) definition of usability. ISO 9241-11 (1998) defined usability as *the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments*. The adopted definition highlights three usability goals, namely effectiveness, efficiency and satisfaction (which are considered to be the focal point for the usability evaluation conducted in this research study). Therefore, the focus of usability in this study is to evaluate the usability of PIAs incorporated in SMOS to support the users in achieving their goals.

Thus, in the context of this study, the task remains to prove that PIAs incorporated in SMOS can not only improve the computer literacy training for adult computer illiterates and meet each individual's training goals, but also provide each of them with a possible means of mastering certain computer skills. User testing (specifically performance measurement) was used to assess the usability of PIAs incorporated in SMOS. Additionally, inquiry methods such as questionnaires and interviews (Chapter 2) were also used. This would attempt to determine whether the incorporation of PIAs could improve the adult computer illiterates' performance when compared to the conventional computer training method.

1.2 Research Problem

Similar to other developing 3rd world countries, South Africa (SA) is also challenged by adult illiteracy. The term *adult illiterate* refers to a person with little or no formal education. According to Professor Solomon Sibiya of the University of Pretoria, illiteracy among black adults in SA has reached a level that is untenable for the economic development of the country. It is preventing both young people and adults from effectively participating in the social, economic and political life in the new SA (Continental Corporation, 2010).

Illiteracy is one of the factors influencing the high level of computer illiteracy and technological ignorance among the population in SA. Computers have become part of our daily lives. Many work opportunities require the use of computers as part of everyday tasks. There is a need to find better ways to support illiterate people in SA so that they can become part of the workforce, gain self-confidence and take part in social activities. This support can be achieved by providing illiterate people with the necessary learning opportunities, such as basic computer training, to promote their skills development for employability.

As already mentioned in Section 1.1.2, computer training nowadays is mostly conducted using conventional training and e-learning approaches. These kinds of training approaches might present a set of challenges for those less familiar with technology, or less educated (both young and older) adults. These challenges could be caused by the persons' reluctance to embrace new technology, their uncertainty about their computing knowledge, or fear of the unknown. Hence, it is critical to find ways to overcome some of the constraints that may occur in computer-based learning environments.

With the advances in technology, computer-based learning environments can be designed to support simulated social interactions between the learner and the computer (Kim, Baylor and Shen, 2007). For several years now, among Human-Computer Interaction (HCI) researchers, there has been an increased effort towards developing innovative tools to facilitate users' interaction with computers. The main motive behind these tools was to reduce novice users' perception of the learning difficulty level of the material, as well as to help them to manage or recover from negative emotions that might arise during their interactions with computers. The PIAs introduced in subsection 1.1.1.1 are one example of such an innovative tool.

Taking the above into consideration, the current research is seen as an initial step towards finding ways to incorporate PIAs to simplify computer literacy training (specifically in a word processing environment) for adult computer illiterate users in SA. This research was conducted with the co-operation of a group of adult learners from the Mangaung-University of the Free State Community Partnership Programme (MUCPP) based in Bloemfontein, SA. These adults could understand and speak English (although it was not their first language), but had little or no formal post-school education or exposure to computers. They were introduced, trained and assessed using the SMOS developed by Potgieter (2010) at the University of the Free State. This simulated word processor system incorporated a variety of PIAs (varying in terms of e.g. appearance, gender, voice and reality). The focal point of this research was to assess the extent to which this variety of PIAs could assist adult learners in acquiring basic computer skills without compromising the quality of the training (Mabanza and De Wet, 2014a).

1.3 Research Question

Based on the research problem mentioned in Section 1.2, the following main research question was pursued in this research study:

What is the level of usability of PIAs used in adult computer literacy training?

The usability of PIAs was a measure of the effectiveness, efficiency and satisfaction with which adult learners could achieve their computer-training goals using PIAs. This led to the following secondary research questions:

- How effective is it for adult learners to perform their computer training tasks with the assistance provided by PIAs?
- How efficiently can adult learners complete their computer training tasks with the assistance provided by PIAs?
- How do adult learners feel about their ability to accomplish their computer training goals using PIAs?

1.4 Research Aims and Objectives

The aim of this research is to establish, through user testing (refer to Section 1.1.3), whether the incorporation of a variety of PIAs can improve and facilitate the computer literacy training for adult computer illiterates in SA. To achieve this aim, the following research objectives will be pursued:

- Carry out a comprehensive literature review in which the following aspects will be covered:
  - Notion of agents, different types of agents, their use and application domains, existing PIAs, including studies on PIAs;
  - Adult learning and adult computer literacy training; and
  - Usability and usability evaluation methods.

- Plan and perform the user testing. The user testing will serve the following purposes:
  - Measure the usability attributes (effectiveness, efficiency and satisfaction) of incorporating PIAs in adult computer literacy training.

- Effectiveness will have one measurable indicator, namely number of errors.
- Efficiency will have one measurable indicator, namely task effort (e.g. number of steps completed in a given task).
- Satisfaction will have two measurable indicators, namely (i) users' subjective opinions in terms of their satisfaction levels with the system they used during user testing (i.e. SMOS for the group who used PIAs, and MS Word for those who did not use PIAs), and (ii) their satisfaction levels with regard to their participation in the study (i.e. amount learnt from the study, enjoyment of being part of the study, and willingness to participate in a similar study in future).

- Use the user testing results to present guidelines with regard to key aspects to improve adult computer literacy training in SA and draw conclusions to:
  - Identify the changes in knowledge, attitude and aspiration of computer literacy training program participants based on their computer literacy training with PIAs; and
  - Propose ways in which to incorporate PIAs in order to improve adult computer literacy training.

1.5 Hypotheses

The aim and objectives discussed in Section 1.4 above led to the formulation of the following three hypotheses:

$H_{0,1}$: There is no difference in the usability performances in terms of effectiveness (number of errors) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.

$H_{0,2}$: There is no difference in the usability performances in terms of efficiency (task effort) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.

$H_{0,3}$: There is no difference in the user satisfaction in terms of amount learnt from the study overall, enjoyment of being part of the study, and willingness to participate in a

similar study in future when using PIAs in adult computer literacy training compared to using conventional computer training techniques.

1.6 Research Paradigm and Methodology

This section will introduce and briefly discuss the research paradigm and methods that will be used in this study, including the data analyses that will be performed.

1.6.1 Paradigm and Methods

The pragmatist paradigm was selected as a suitable paradigm for the current study. This research study employed the convergent parallel mixed-methods research design. In this design quantitative and qualitative data are given equal importance. As a result, these two forms of data are collected and analysed simultaneous, but separately, such that one is not influencing the other. The results of these two data types are integrated during the data interpretation stage by means of comparison and contrast. The convergent parallel mixed-methods allow confirming, cross-validating or corroborating findings in a single study (Creswell, 2009). Reliability and validity of this study have been addressed through the use of multiple sources of data that are relevant to the current research aims and objectives. Furthermore, all aims, objectives, justifications of the adopted research paradigm and methods, decisions and procedures were clearly specified.

Quantitative data were collected by means of user testing whereby 32 control group participants and 71 test group participants completed 11 tasks using their respective word processing systems. The control group participants used the MS Word system and the test group participants used the SMOS, which incorporated 10 different kinds of PIAs.

Qualitative data were obtained using self-developed questionnaires (i.e. pre-training and post-test questionnaires), observation and interviews. Chapter 3 provides a detailed discussion of the research design and methodology used in this study.

1.6.2 Analysis

Data were analysed through comparative statistical test techniques (i.e. t-test, chi-square test, the one-way generalised linear model, the two-way generalised linear model, and Fisher's

exact test) using the Statistical Package for the Social Science (SPSS) and Statistical Analysis System (SAS) software packages.

The comparative statistical test for the usability performance data (effectiveness and efficiency) aimed mainly to compare control and test group participants' performance data with respect to the following outcome variables:

- Number of errors
    - Statistical analysis was done in this study in order to better compare the effectiveness of control and test group participants based on:
        - Number of errors per each individual task, and
        - Total number of errors.

- Tasks effort
    - Number of steps completed in a given task was used to compare the efficiency of the control group participants and the test group participants.

- Satisfaction with word processing system (participants' subjective impressions with regard to the respective word processing system that they used during user testing):
    - For the control group participants: satisfaction levels (i.e. subjective impressions) with MS Word processing system;
    - For the test group participants: satisfaction levels (i.e. subjective impressions) with different kinds of PIAs incorporated in SMOS.

- Satisfaction with study:
    - Enjoyment of being part of the study;
    - Amount learnt from the study overall; and
    - Willingness to participate in a similar study in future.

Observations and interview data were used to complement and better understand the performance (effectiveness and efficiency) and the satisfaction data:

- Observations

  The observations data were used to compare the test group and the control group participants' observable behaviours and attitudes while using their respective word processor systems during the user testing.

- Interviews

  Interview data served to gain more insight into some of the test group and the control group participants' behaviours and preferences that were not clearly understood during the observation.

1.7 Research Limitations

The following can be seen as limitations of this research project:

- The SMOS is a word processor, developed for the purpose of this study, with limited features and functions necessary only for the purpose of this study.
- The PIAs incorporated in SMOS used natural language in English to communicate with participants. For this reason study participants will consist of only adult learners who could understand and speak English.
- Study participants received basic computer literacy training. As a result, not all word processing tasks were included in the training. Those included consisted only of a selected number of basic word processor tasks considered to be relevant for the scope of the study. For this reason complex word processor tasks were not included.
- Study participants consisted of persons having little or no previous practical experience with computers. It was expected that those who lack computer exposure will find it challenging to familiarise themselves with computers (i.e. clicking the mouse or using the keyboard to type). Hence, to avoid putting unnecessary pressure on the participants, some aspects of efficiency, such as time taken to complete the tasks, were not captured in this study. The number of steps taken to complete a task (i.e. task effort) was the only efficiency aspect considered in this study.

1.8 Research Contributions

This research will cover a number of issues surrounding adult education and PIAs. As far as the contribution of this study is concerned, it throws light on how (if at all) PIAs can enhance computer literacy training in a 3rd world context (in terms of better quality training and

reaching more people simultaneously without the restriction of not having enough human instructors). Being trained to become computer literate could throw a lifeline to many adults with little or no post-school education by giving them a better chance at finding a job with career growth prospects.

This study will be beneficial to the research community in the following ways:

- Although a number of research studies have been conducted in the field of PIAs, there is currently no study that investigated the use of PIAs in a word processor environment.
- Adult computer illiterate users with no formal post-school training in the context of 3rd world countries were the population used for this study. Little is known about studies in the field of PIAs that have specifically examined this kind of population. Therefore, this research can be seen as an attempt towards finding suitable techniques of user testing for measuring usability of PIAs in adult learning environments in the context of 3rd world countries.
- In general, the research outcomes can also be considered as a positive contribution in the attempt to find a way of addressing computer illiteracy currently faced by developing countries, in this case especially in SA.

1.9 Research Outline

A schematic representation of the research study outline is shown in Figure 1.2 below.

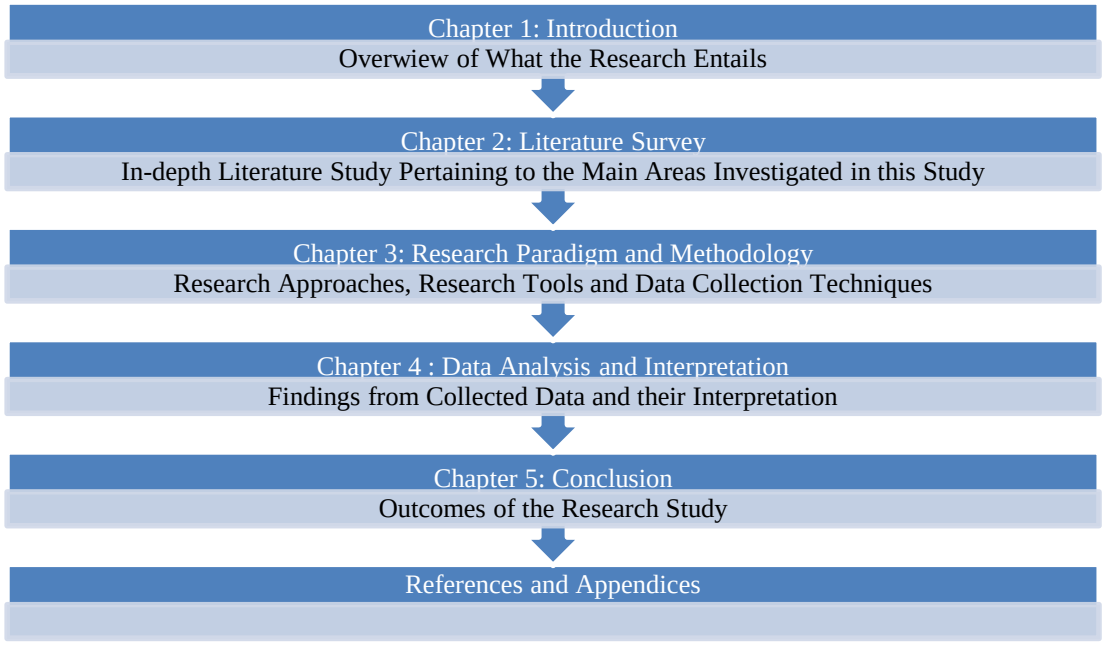


Figure 1.2: Outline of Research Study

The dissertation will consist of five chapters:

Chapter 1 provides an introduction to the research study. The motivation for the research, including the research problem, questions, aims, objectives and hypotheses that provide direction for the work, are discussed. The research design and methodology, limitations and lastly the contribution and organisation of the research study are briefly explained.

Chapter 2 will lay the foundation for the rest of the study. It will briefly introduce terms and principles, previous related work focusing on PIAs and usability testing techniques.

Chapter 3 will describe in detail the different methodologies and approaches used to conduct the data needed for the purpose of this study. The user testing design, the features of the research tool (SMOS), and the test suite set-up that will be used to carry out the user testing will also be described in this chapter.

Chapter 4 will present analyses, interpretations and discussions of the results obtained from the user testing as described in Chapter 3. Lastly, a comparison of the various usability test results obtained will be done.

Chapter 5 will be a conclusive chapter. It will present the conclusions about the research question investigated. It will also mention lessons learnt, limitations of the current research, and finally suggest future research directions.

1.10 Summary

In this chapter the research project was motivated in terms of the problem of the high number of adult computer illiterate people in 3rd world countries, such as SA. Computer illiterate people need to be assisted to acquire the skills necessary to successfully enter the job market and to become part of the economy. One main research question and three secondary research questions were stated, and the research aim and objectives were also established. The research aim and objectives were expressed as three null-hypotheses. The pragmatist paradigm was chosen as a suitable paradigm for this study, while convergent parallel mixed-methods research was found to be the appropriate methodology. Comparative statistical test

techniques were identified as the means for conducting the data analysis. Study limitations were mentioned, as well as opportunities for further research. The chapter concluded with an explanation of the contributions of the study, including a proposed guideline on how to incorporate PIAs to facilitate adult computer literacy training in a 3rd world country such as SA. A literature review will now be presented in Chapter 2.

Chapter 2: Literature Survey

2.1 Introduction

As shown in Figure 2.1, Chapter 2 gives an overview of educational agents and related terminology. This chapter further reviews previous research studies that were performed in the field of educational agents. Other topics of interest that will be introduced and discussed include adult learning, adult computer literacy training and usability.

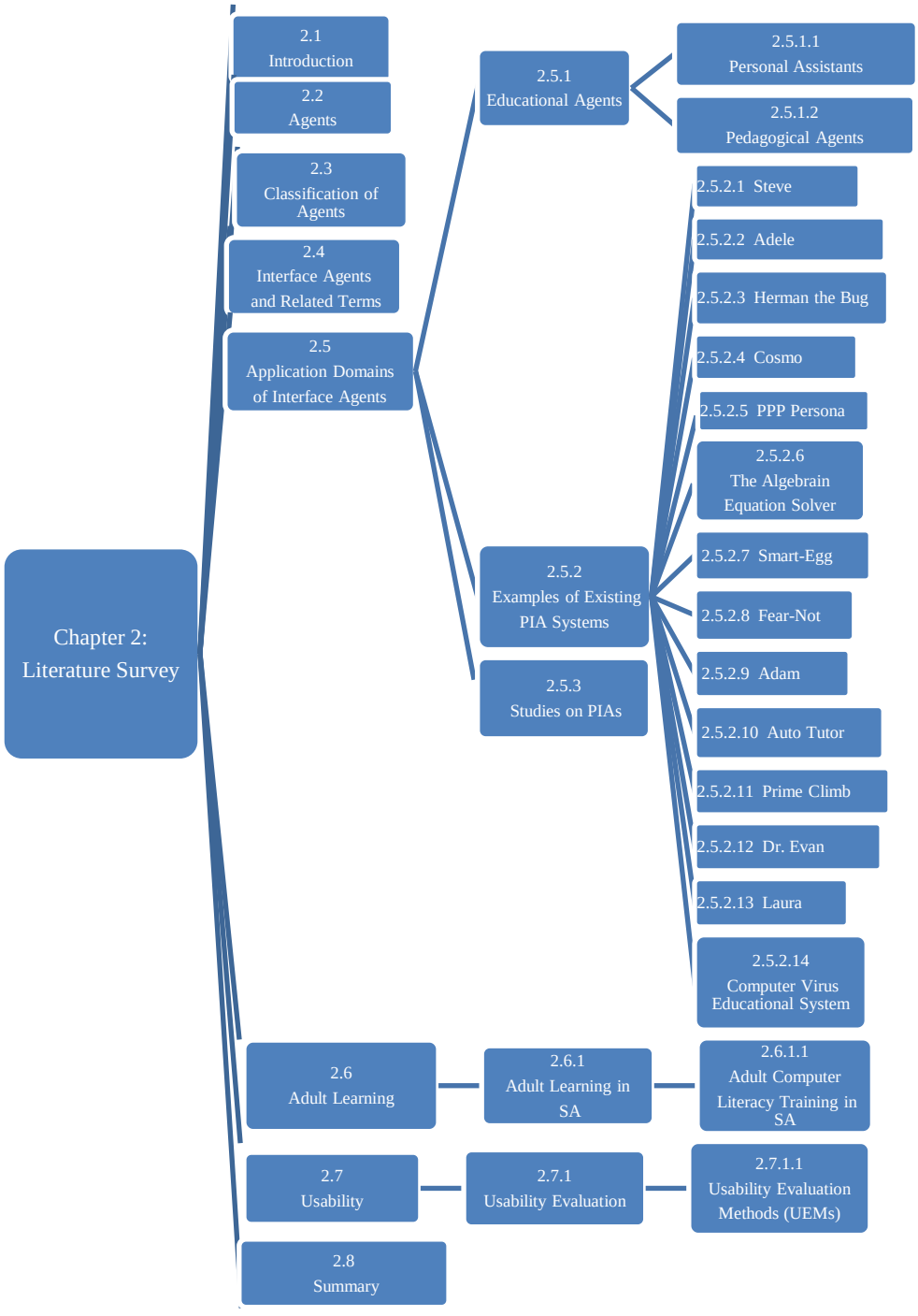


Figure 2.1: Schematic Representation of Chapter 2

2.2 Agents

As mentioned in Section 1.1.1, an agent can exhibit a particular characteristic or combination of characteristics. A few examples of these characteristics include being reactive, autonomous, goal driven or pro-active, communicative, adaptive or learning, benevolent, deliberative, temporally continuous, mobile, flexible and representing a character (Elmahalawy, 2012; Etzioni and Weld, 1994; Franklin and Graesser, 1996; Giraffa and Viccari, 1998; Meenakshi *et al*., 2010; Shonali, 2005). The meaning of each of these characteristics is explained in Table 2.1.

Table 2.1: Agents' Characteristics (Adapted from Franklin and Graesser, 1996)

Property	Meaning
Adaptive or learning	Ability to adjust its current behaviour or gain new behaviour to better adapt to its present surrounding or environment.
Autonomous	Ability to act alone without the intervention of humans or other agents.
Benevolent	Able to help other agents.
Communicative	Able to communicate with other agents in its surroundings.
Deliberative	Ability of the agent to decide on how to engage with other agents.
Flexible	Ability of the agent to respond to possible internal or external changes influencing its environment.
Goal driven or pro-active	Ability to take action in an organised manner in order to execute its intended goals.
Mobile	Ability of the agent to move itself from one place to another.
Reactive	Ability to react / respond to whatever is happening in its environment.
Representing a character	Ability of the agent to have human traits and emotional states.
Temporally continuous	A process running continuously with respect to time.

The existence of various characteristics of an agent (see Table 2.1) has led to a variety of proposed agent definitions in the Artificial Intelligent (AI) research community (Giraffa and Viccari, 1998; Rudowsky, 2004; Shonali, 2005). A few examples of these suggested definitions are listed in Table 2.2.

Table 2.2: Agent Definition

Source(s)	Definition
Alagar, Holliday, Thiyagarajan and Zhou (n.d.)	An agent is a software component designed to achieve certain goals.
Gavalas *et al.* (2009)	The term *agent* is used to denote a (usually static) software entity with a well-defined role, typically acting on behalf of a human or another software component, which may be used in a variety of applications.
Koch and Rahwan (2004)	An agent is an autonomous computer system that is situated in an environment, and is capable of flexible autonomous behaviour in order to meet its design objectives.
Merriam-Webster Dictionary (2013)	An agent is a computer application designed to automate certain tasks (such as gathering information online).
Sowa (2001)	An agent is an animate entity that is capable of doing something on purpose.

The similarity between the definitions in Table 2.2 is that they all defined an agent in a broader way focusing on two concepts, namely the agent's role and purpose. Moreover, the main difference between these proposed definitions lies in the manner in which a particular agent needs to fulfil its intended role(s). For example, the definitions of Gavalas *et al*. (2009), Koch and Rahwan (2004), the Merriam-Webster Dictionary (2013), and Sowa (2001) outlined that a particular agent needs to be autonomic to fulfil its intended role, whereas Alagar *et al*. (n.d.) emphasised the pro-active (goal-oriented) characteristic of the agent. The definitions of Gavalas *et al*. (2009) and Koch and Rahwan (2004) outlined both autonomy and pro-active (goal-oriented) as essential for a particular agent to fulfil its intended role.

This study is an endeavour to find ways to facilitate the computer literacy training for adult computer illiterate users by using agents. Therefore, it will be crucial for these agents to exhibit essential characteristics (or a combination of) that will assist to achieve their intended roles (i.e. facilitate the training for adult learners). Hence, based on the previous discussion, the agent definition opted for in this study is also broader, similar to the ones in Table 2.2. The difference is that the adopted definition combines definitions of Gavalas *et al*. (2009), Koch and Rahwan (2004), and the Merriam-Webster Dictionary (2013) to form a single definition emphasising agents' characteristics, which are judged to be useful for the aims of this current study. For the purposes of this current research study, the term *agent* will be defined as follows:

An agent is an autonomous computer system with a precise, goal-oriented task, capable of acting on behalf of a user (human) to automate computer related tasks in a communicable way to meet the (human) user's needs.

In the next section, the different types of agents will be discussed.

2.3 Classification of Agents

Literature reveals that there are many possible proposed agent classification schemes. These classification schemes depend on the various sets of aspects by means of which agents can be classified. For example, Franklin and Graesser (1996), Habibi (2010) and Shonali (2005) identified seven different schemes by means of which agent classification can be made. These seven schemes include the following: crucial characteristics being emphasised on a particular agent, tasks performed by a particular agent, the environment where a particular agent finds itself, a particular agent's control mechanism, how much internal state a particular agent possesses, the range of sensitivity of a particular agent, and the effectiveness of a particular agent's actions.

Although there are several agent classification schemes, most researchers referred to the one proposed by researchers from the BT Labs. In the classification schema proposed by BT Labs, crucial characteristics being emphasised on a particular agent are considered to be the principal criteria for agent classification. In line with that, BT researchers proposed four dimensions of agent topology, namely mobility, behavioural model, primary attributes and roles (Meenakshi *et al*., 2010; Moraitakis, 1997; Nwana, 1996). Each of these will be briefly explained.

Mobility refers to the capability of an agent to carry out autonomously a set of actions in a given environment in order to accomplish a variety of tasks such as communicate and cooperate with other agents, move around some networks (Meenakshi *et al*., 2010; Moraitakis, 1997; Nwana, 1996; Shonali, 2005). Therefore, based on a particular agent's mobility, it can be classified as a static or mobile agent.

The behavioural model characteristic of an agent refers to the agent's internal states, including the manner in which an agent models its environment. Based on that, an agent can be classified as a deliberate agent or a reactive agent. The main difference between these two is that a deliberate agent possesses an internal model (i.e. use deliberation), whereas a reactive agent lacks an internal model (i.e. no deliberation).

Primary attributes refer to the most important qualities that an agent should exhibit, namely autonomy, learning and cooperation (Meenakshi *et al*., 2010; Moraitakis, 1997; Nwana, 1996). Autonomy refers to the ability of an agent to operate independently without human guidance controlling interference. Learning refers to the ability of an agent to adjust its behaviour in order to better adapt to its present environment. Cooperation refers to the capacity of an agent to work mutually with other agents to accomplish a complex task. Depending on the manner in which an agent exhibits each of the three characteristics explained above, an agent can be classified either as a collaborative agent, a collaborative learning agent, an interface agent or a smart agent.

The characteristics of a particular agent can also be determined based on the roles that it plays in a given environment. This usually applies when the character assigned to an agent is a major character. In this case, an agent can be classified as an information or Internet agent (e.g. Internet search engine).

In addition to the four dimensions of agent topology explained above, there is another type of agent, which is referred to as a hybrid agent. Hybrid agents result from a combination of agents from two or more categories (philosophy) forming a single agent (Meenakshi *et al*., 2010; Nwana, 1996).

It is possible to identify other attributes by means of which agents can be classified, referred to as secondary attributes. Examples of secondary attributes include versatility (i.e. an agent's capability of doing a variety of tasks), benevolence, competitiveness and veracity (Meenakshi *et al*., 2010; Nwana, 1996; Shonali, 2005).

The four dimensions of agent topology proposed by BT researchers had given way to seven important categories of agents, namely collaborative agents, interface agents, mobile agents, information/Internet agents, reactive agents, hybrid agents and smart agents (Meenakshi *et al*., 2010; Moreno, 2010; Nwana, 1996; Shonali, 2005).

The researcher is aware that even though the researchers from BT Labs have made enormous contributions in the field of agent research, at times their proposed agent classification might be arguable. This is due to the lack of common agreement in the AI research community about the kinds of characteristics (or combination of characteristics) that define an agent.

Nonetheless, literature shows that the proposed agent classification by BT Labs is the most accepted in the research community.

Taking into consideration the earlier discussions, in the context of this study the researcher has adopted to use the proposed BT Labs' agent classification. Among the seven types of agents proposed by researchers from BT Labs (i.e. Nwana), the interface agents will be the focus of this research study.

2.4 Interface Agents and Related Terms

Several interchangeable terms have been used in the research community when referring to interface agents. These include anthropomorphic interface agent, conversational agent, embodied agent, embodied conversational agent, animated interface agent, emotional interface agent, intelligent (virtual) agent, lifelike character, animated character, interface character, user interface agent and virtual human. Although researchers used interchangeable terms, literature revealed that *interface agent* remains the most used term within the AI community. Hence, in the context of this study, the researcher preferred to use the term *interface agent*.

There is no unique way to describe exactly what an interface agent is. As a result, there are many definitions that have previously been suggested by researchers. Table 2.3 presents a few examples of these suggested definitions.

Table 2.3: Definitions of an Interface Agent

Source(s)	Definition
Dictionary.com (2013)	An interface agent is an intelligent agent that is intended to communicate with people, such as a chatbot.
Lincicum (2003)	An interface agent is a character enacted by a computer that interacts with the user in a socially engaging manner.
Maes and Kozierok (1993)	An interface agent is a computer program that employs AI techniques in order to provide assistance to a user dealing with a particular computer application.
Schiaffino and Amandi (2006)	An interface agent is a computer program that provides personalised assistance to users with their computer-based tasks.
Serenko, (2006)	An interface agent is a reactive, collaborative and autonomous visual computational system, which communicates directly with a person offering assistance and advice in performing computer-related tasks.

All the definitions listed in Table 2.3 recognise that interface agents support and provide assistance to the user. The definitions by Dictionary.com (2013), Lincicum (2003) and

Serenko (2006) are the only ones that also point out some of the essential characteristics (see Table 2.1) that agents should possess in order to achieve their goals (i.e. support and provide assistance to the user). In addition, in both the definitions of Dictionary.com (2013) and Serenko (2006) the communication characteristic of an interface agent is highlighted in a broader sense. Among all five definitions, only the definition by Lincicum (2003) indicates the way that interface agents should relate with the user (i.e. socially engaging manner).

Therefore, the definition opted for regarding the purposes of this study combine the definitions of Lincicum (2003) and Serenko (2006) into a single definition. This single definition brings to light interface agents' characteristics that the researcher judges necessary for the purposes of the current study. Hence, for the purposes of this current research study, an interface agent will be defined as follows:

An interface agent is a reactive, collaborative and autonomous visual character enacted by a computer that communicates with a user in a socially engaging manner, offering him/her assistance in completing computer-based tasks.

From the above definition, it can be inferred that interface agents act as intermediaries between a user and a computer. Therefore, in order to better support and provide assistance to the user interface agents are sometimes represented anthropomorphically. More generally, anthropomorphism is defined as the attribution of human traits or behaviour to non-human objects such as robots, computers and animals (Bartneck, Croft and Kulic, 2008).

Collins (2007) pointed out that anthropomorphism has a dual purpose:

- Creating a kind of *human-like* interaction between the user and the computer; and
- Improving the automation of tasks.

To ease the interaction between the user and the computer, human-like traits are expressed at the computer interface-level in terms of appearance, personality and behavioural style. The fundamental reason for doing so is to produce an emotional response that forms a relationship between the user and the computer interface (Morgan, 2013).

It is well known that the use of anthropomorphism is a controversial debate in HCI (Preece, Rogers and Sharp, 2011). This has led to a wide range of debates and arguments between those in favour of and those against anthropomorphism. Those in favour of anthropomorphism tend to view it as an effective design method because it facilitates certain social modes of interaction. Those against argue that it establishes false expectations and creates dangerous relationships with machines (DiSalvo and Gemperle, 2003).

The debate on whether to use anthropomorphism or not is beyond the scope of this research study. Thus, in the current research study, the research will rather focus on investigating its uses in adult educational training, specifically the possibility of using anthropomorphism to provide computer training support for adult computer illiteracy in 3rd world countries.

The application domains of interface agents will now be investigated.

2.5 Application Domains of Interface Agents

Agents are used or implemented in different disciplines and application domains. The following are a few examples of these application domains:

- E-commerce
  An agent can act as an e-commerce assistant that provides consumers with information or advice about products.
- Entertainment
  An agent can act as a character in a video game.
- Medicine
  An agent can represent a doctor, nurse or therapeutic assistant in a medical application.
- Education
  An agent can assist a learner or teacher in the completion of pedagogical/educational tasks.

Educational agents will be the core of this research study. The current research study will investigate their uses in adult educational training, specifically the possibility of using educational agents to provide computer training support for adult computer illiteracy.

2.5.1 Educational Agents

Sometimes researchers use different terms, such as animated pedagogical agents, animated conversational agents, intelligent agents, instructional agents, lifelike characters, virtual human agents, computerised agents, avatars, chatbots, and guideboots when referring to educational agents (Atan, Keong, Aris, Luan, Majid and Rahman, 2008; Clarebout and Heidig, 2012; Kuligowska, 2015; Savin-Baden, Tombs and Bhakta, 2015; Theodoidou, 2011; Wolfe, Wildmer, Weil, and Cedillos-Whynott, 2015). In the context of this study, the researcher used the term *educational agents*. Educational agents can be defined as *pieces of educational software presented on a computer screen that include human characteristics and that facilitate learning in a social engaging manner through a multimedia environment* (Clarebout and Heidig, 2012; Lieberman and Selker, 2003; Serenko, 2006). Therefore, in order to efficiently fulfil their learning facilitating functions (duties) educational agents often take on human-like characteristics, which is frequently expressed in graphical form, icons, voice, animation, multimedia, virtual reality or textual form (Chou *et al*., 2003; Veletsianos, Yerasimou and Doering, 2005). This further allows the interaction between the user and the computer to take place in a way that is familiar to the users.

Over the years various classifications of educational agents have been proposed. However, the classification most cited in the research community is the one proposed by Chou *et al*. (2003), which the researcher adopted in this study. The adopted classification divides educational agents into two major categories, namely personal assistants and pedagogical agents.

2.5.1.1 Personal Assistants

Personal assistants are educational agent types that play informative roles in the learning environment. It provides the teacher or the learners with the necessary information related to the learning activities, but does not become directly involve in those learning activities (Chou *et al*., 2003; Landowska, 2008). A personal assistant can perform as a teacher's assistant or a learner's assistant (Landowska, 2008).

- **Teacher's Assistant**

A personal assistant provides a teacher with information such as a student's learning portfolio or learning performance.

- **Learner's Assistant**

A personal assistant assists students in gathering information to carry out learning activities, such as arranging instructors, tutors, etc.

2.5.1.2 Pedagogical Agents

Unlike personal assistants, pedagogical agents are specifically designed to support important instructional roles and guide users through the learning process (Schroeder and Adesope, 2013; Veletsianos and Miller, 2008). They can communicate with the learner in natural language (Atan *et al.*, 2008; Landowska, 2008). Pedagogical agents can serve different purposes, such as acting as a tutor or co-learner (Landowska, 2008).

- **Tutor**

As a tutor, a pedagogical agent plays the role of an expert (Atan *et al.*, 2008; Landowska, 2008). It can provide instructional information, give tips, answer questions or provide explanations about a given subject within a particular domain (i.e. language, economics, botany, computer, etc.) that the agent is knowledgeable about.

- **Co-learner**

A pedagogical agent can also play the role of a classmate, a learning companion or a teammate (Atan *et al.*, 2008; Landowska, 2008). The agent is judged to be at the same level as the student. As a result, it does not have the knowledge nor provides answers, but it stimulates the learner to achieve the learning goals.

Figure 2.2 provides a graphical summary of the different types of educational agents discussed above. The various items that appear in bold and are underlined represent the focus of this study.

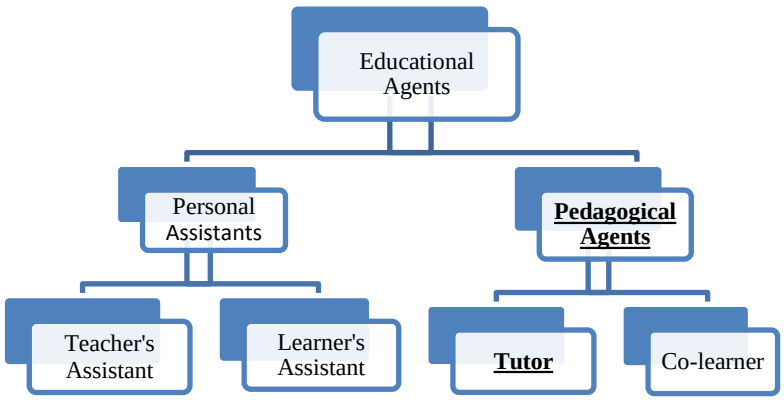


Figure 2.2: Overview of Educational Agent Classification

Among the different types of educational agents shown in Figure 2.2, pedagogical agents, specifically the ones acting as tutor, will be the focal point of this research study. Furthermore, for the remainder of this research study, the term *Pedagogical Interface Agents (PIAs)* will be used when referring to pedagogical agents, specifically those agents who play the role of a tutor. Examples of PIAs will be given in the following section.

2.5.2 Examples of Existing PIA Systems

A literature search on PIA systems indicated that quite a number of PIA systems have been developed over the years in research laboratories by different research groups or by individual researchers globally. This section begins by providing a selection of PIA systems developed by leading research laboratories. These include Soar Training Expert for Virtual Environments (Steve), Agent for Distributed Learning Environment (Adele), Herman the Bug, Cosmo, PP Persona, and the Algebrain Equation Solver. Each of these PIA systems will be briefly discussed.

Steve (Steve In Action, 2000) and *Adele* (Johnson, 2000) are examples of two of the most popular agents developed by the Centre for Advanced Research in Technology for Education (CARTE) at the University of Southern California (USC).

2.5.2.1 Steve

Steve (Steve in action, 2000), shown in Figure 2.3, is an instructor within a network virtual environment. It was designed for the purpose of assisting in naval training tasks such as operating engines and helping and guiding United States Navy surface ships. It can support both individual and personal training.

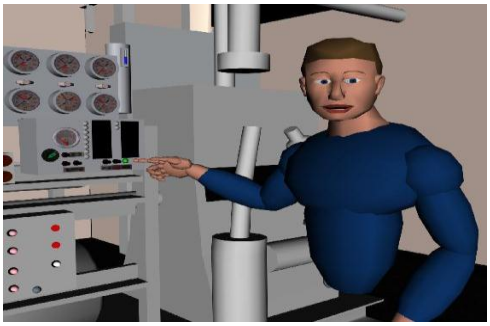


Figure 2.3: Steve (Steve in action, 2000)

2.5.2.2 Adele

Adele was designed to run on the desktop platform (e.g. the learner's browser). She is a virtual medical specialist who supports online case problem solving, particularly in family medicine and on graduate level geriatric dentistry. Adele monitors students as they work through a simulated case. It compares the students' actions against a model of how the task should be performed. Adele (Johnson, 2000) is shown in Figure 2.4 below.

Figure 2.4: Adele (Johnson, 2000)

The Multimedia Laboratory at the North Carolina State University has also developed two agents: *Herman the Bug* (Herman the Bug, 1998) and *Cosmo* (Lester *et al*., 1997).

2.5.2.3 Herman the Bug

Herman the Bug inhabits a virtual environment. It helps middle school students between the ages of 10 and 14 to understand botanical anatomy and physiology. Its purpose is to advise students as they design plants to survive in various hypothetical environments. It explains what plants for certain environments should look like and gives instructions on botanical anatomy. A picture of Herman the Bug (Herman the Bug, 1998) is displayed in Figure 2.5.

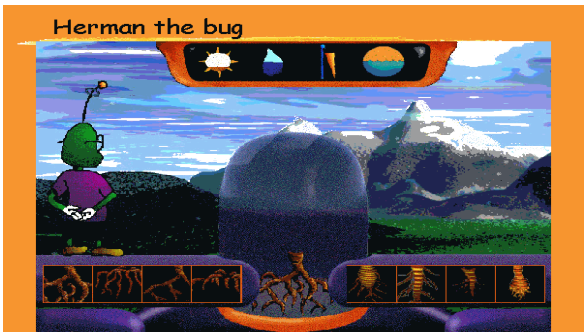


Figure 2.5: Herman the Bug (Herman the Bug, 1998)

2.5.2.4 Cosmo

Like Herman the Bug, Cosmo (Figure 2.6) was also developed to inhabit 3D virtual environments. It plays the role of a virtual Internet advisor in a learning environment for Internet packet routing. Its purpose is to advise students on Internet packet routing mechanisms. Cosmo (Lester *et al*., 1997) assists students in finding a route to transmit between network hosts, avoiding high traffic.

Figure 2.6: Cosmo (Lester *et al*., 1997)

2.5.2.5 PPP Persona

PPP Persona (André *et al*., 1996) is another example of an agent developed at the German Centre for AI, Deutsches Forschungszentrum für Kunstiche Intelligenz (DFKI). Its purpose is to guide the learner through Web-based materials using presentation acts to draw attention to the elements of Web pages. PPP Persona is shown in Figure 2.7.

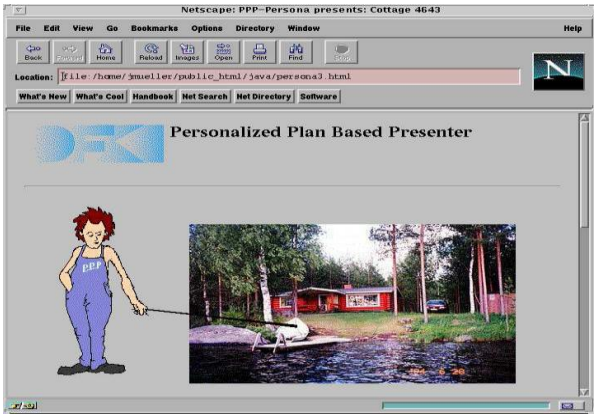


Figure 2.7: PPP Persona (André *et al*., 1996)

2.5.2.6 The Algebrain Equation Solver

The Algebrain Equation Solver (Alpert *et al*., 1999) in Figure 2.8 is an agent that solves equations for a particular variable. It was developed by IBM's T.J. Watson Research Centre. It supports students' problem solving activities to enhance their problem solving skills.

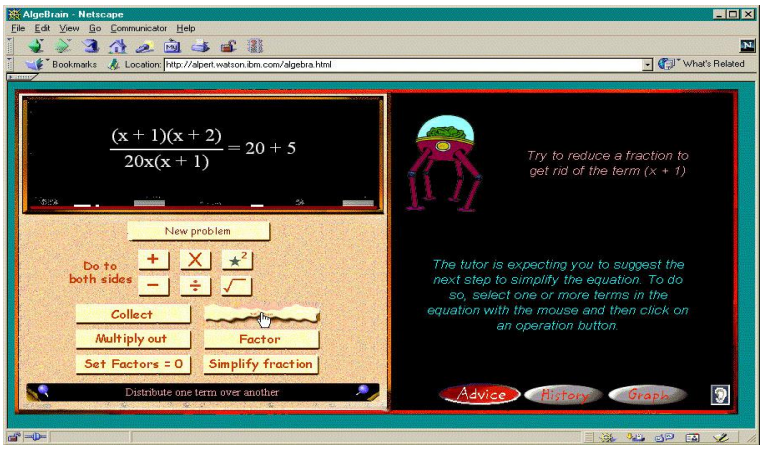


Figure 2.8: Algebrain Equation Solver (Alpert *et al*., 1999)

Additional to the PIA systems mentioned above, there are also several other PIAs developed by other researchers for various learning domains. The majority of these systems were inspired by some of the earlier works highlighted above. Smart-Egg, Fun with Emphatic Agents Reaching Novel Outcomes in Teaching (Fear-Not), Adam, Auto Tutor, Prime Climb, Dr Evan, Laura and the Computer Virus Educational System, are just a few examples and will now be discussed briefly.

2.5.2.7 Smart-Egg

Smart-Egg (Suraweera and Mitrovic, 1999) is an animated PIA system designed to assist students in learning Structured Query Language (SQL). Smart-Egg is shown in Figure 2.9.

Figure 2.9: Smart-Egg (Suraweera and Mitrovic, 1999)

2.5.2.8 Fear-Not

Fear-Not (Aylett *et al*., 2005) was created as part of the European Union (EU)-funded project Virtual Information Computer Technology with Empathic Characters (VICTEC). Its aim is to allow children to, in an unthreatening environment, explore what happens when bullying takes place, and where they have to take responsibility for what happened to a victim, without themselves feeling victimised. In other words, Fear-Not serves as a tool for educating children against bullying behaviour in school environment. Fear-Not is displayed in Figure 2.10.

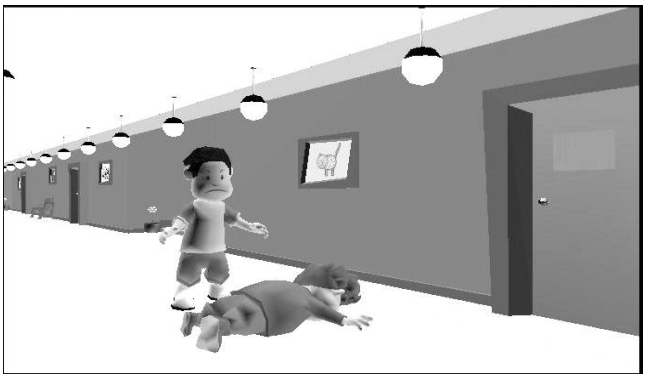


Figure 2.10: Fear-Not (Aylett *et al*., 2005)

2.5.2.9 Adam

Adam (Gilbert *et al*., 2005), as shown in Figure 2.11, is an example of a Web-based adaptive instruction system that uses animated PIAs as teachers for teaching students C-programming concepts in an introductory-level C-course. Adam incorporates different types of animated PIAs with different personalities (e.g. voice, ethnicity). Students have the privilege to select an animated PIA of their choice as a teacher. The agent selected presents instructions to students from an instruction repository of course concepts.

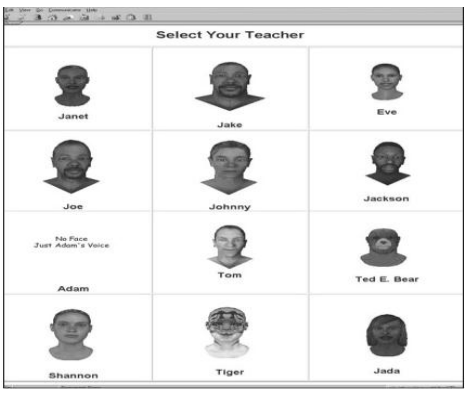


Figure 2.11: Adam (Gilbert *et al*., 2005)

2.5.2.10 Auto Tutor

Auto Tutor (Graesser *et al*., 2003) is another example of an intelligent tutoring system employing a PIA that holds dialog with students (Figure 2.12). It is designed to help college students to learn topics on computer literacy (hardware, Operating Systems, the Internet) and conceptual Physics. The PIA helps students to construct answers to deep-reasoning questions when analysing their responses.

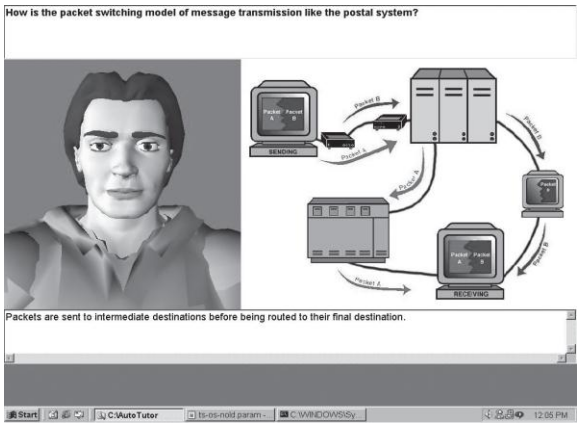


Figure 2.12: Auto Tutor (Graesser *et al*., 2003)

2.5.2.11 Prime Climb

Prime Climb (Conati and Maclaren, 2009) is an educational game for number factorisation (Figure 2.13). It is designed to help 6th and 7th grade students in practising number factorisation. In this narrative learning environment Merlin, the virtual tutor, interacts with learners by recognizing multiple users' emotions during the interaction with an educational game. Additionally, the probabilistic model of user's factorisation knowledge is continuously updated during the user's interaction with the game. As a result, the agent relies on the user's probabilistic model before deciding when to intervene and what hints to provide.

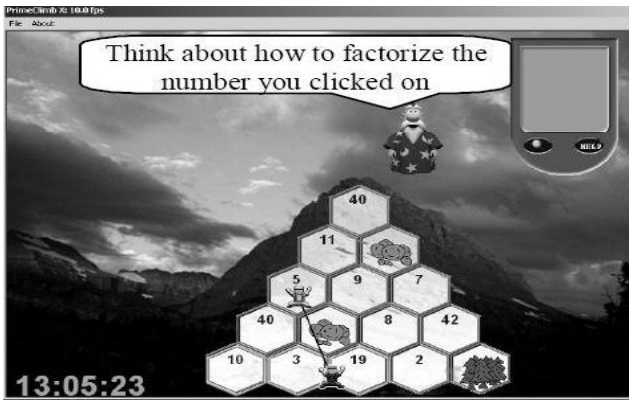


Figure 2.13: Prime Climb (Conati and Maclaren, 2009)

2.5.2.12 Dr Evan

Dr Evan (Bertrand *et al*., 2010), is a virtual PIA who plays the role of a health care inspector. Its principal job consists of interactively teaching and training hospital workers about best practices associated with proper hand hygiene procedures as recommended by the World Health Organisation (WHO). Dr Evan is shown in Figure 2.14.

Figure 2.14: Dr Evan (Bertrand *et al*., 2010)

2.5.2.13 Laura

Laura (Theodoidou, 2011) is a PIA incorporated in a web-based language learning system. Laura, as shown in Figure 2.15, plays the role of a virtual Spanish language instructor specialist. Her core duty consists of teaching Spanish lexical to learners.

Figure 2.15: Laura (Theodoidou, 2011)

2.5.2.14 Computer Virus Educational System

The Computer Virus Educational System (Sabot *et al*., 2005) is a system that uses animated PIAs to teach students a range of subjects, from learning about the basics of computer viruses to the handling and management of computer systems in response to virus attacks. Pedagogical agents incorporated in the Computer Virus Educational Systems perform three main functions, namely tutor, expert and motivator. A tutor agent promotes active learning by offering facilities and coaching. An expert agent directly helps the student, while a motivator

agent displays some emotional responsiveness. The Computer Virus Educational System is shown in Figure 2.16 below.

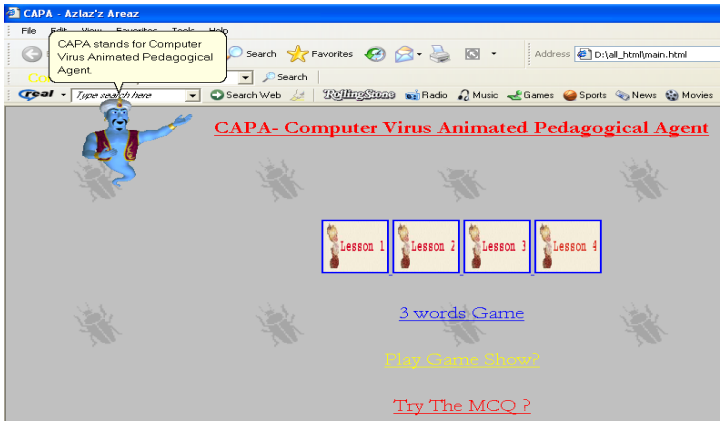


Figure 2.16: Computer Virus Educational System (Sabot *et al.*, 2005)

A brief review of examples of existing PIA systems in this section has revealed that the agents incorporated in these systems play the role of facilitator in a given domain. In the process of performing their facilitators' duties, agents can assume various roles such as advisor, inspector, expert in a particular field, instructor, tutor, etc. PIAs' facilitator roles are being utilised in multidisciplinary instructional domains such as naval training (Steve), human behaviour (Fear-Not), hygiene education (Dr Evan), botanical anatomy (Herman the Bug), language skills (Laura), mathematics (Algebrain Equation Solver, Prime Climb), and medicine (Adele).

In this study, the focal point is on the use of PIA systems in computer instructional environments. Examples of existing PIA systems in this section demonstrated that PIAs are being used in computer instructional fields as well. Some examples include Cosmo (used in computer networks), Smart-Egg and Adam (used respectively in SQL and C-programming), Computer Virus Educational System (used for computer virus education), PPP Persona (used in web content) and Auto Tutor (used for general computer literacy topics). However, the current study is one of the first to particularly focus on computer literacy training using a word processor, namely the SMOS (Mabanza and De Wet, 2014a). SMOS is a PIA word processor system developed by Potgieter (2010) in an effort to enhance word processor training for computer illiterate users or for those who have never been exposed to a computer before. SMOS incorporated various PIAs that play the roles of tutors. Their main purpose consisted of assisting SMOS users (i.e. give them step by step tips) on how to perform various word processor tasks.

All of the existing PIA systems (see Section 2.5.2) incorporated a variety of PIAs by means of users interacting with the system. Adam (see Figure 2.11) seems to be the system which incorporated the most agents (twelve agents). Like Adam, SMOS also incorporated various agents (ten agents). Although SMOS incorporated fewer agents than Adam, the SMOS agents varied in terms of appearance (i.e. realistic, cartoon, and animal), voices, movement and gender. SMOS incorporated two text agents, two text and audio combined agents, two human cartoon agents, two animal cartoon agents, and two realistic animal agents. Each kind of agent included a male and a female. SMOS features will be explained in further detail in Chapter 3. A summary of the main aspects of some of the existing PIA systems discussed earlier is presented in Table 2.4 below.

Table 2.4: Some Existing PIA Systems

Source	Agent	Gender	Appearances	Purpose (instructional field)
Alpert *et al*. (1999)	Algebrain Equation Solver	N/A	Fantasy Creature	Mathematics
André *et al*. (1996)	PPP Persona	Male	Human Cartoon	Web Content
Aylett *et al*. (2005)	Fear-Not	Male	Human Cartoon	Educate Kids about Bullying Behaviour
Bertrand *et al*. (2010)	Dr Evan	Male	Human Cartoon	Hygiene Education
Conati and Maclaren (2009)	Prime Climb	N/A	Fantasy Creature	Mathematics
Gilbert *et al*. (2005)	Adam	Male Female	Human and Animal Cartoons	Computer Programming
Graesser *et al*. (2003)	Auto Tutor	Male	Human Cartoon	Computer Literacy Topics
Herman the Bug (1998)	Herman the Bug	N/A	Fantasy Creature	Botanical Anatomy
Johnson (2000)	Adele	Female	Human Cartoon	Medical School Students
Lester *et al*. (1997)	Cosmo	N/A	Fantasy Creature	Computer Network
Sabot *et al*. (2005)	Computer and Virus Educational Systems	Male	Fantasy Creature	Computer Virus
Steve in action (2000)	Steve	Male	Human Cartoon	Naval Training
Suraweera and Mitrovic (1999)	Smart-Egg	N/A	Egg	SQL Computer Programming
Theodoidou (2011)	Laura	Female	Human Cartoon	Language

The findings of previous studies in the field of PIAs will be highlighted and briefly discussed in the next section.

2.5.3 Studies on PIAs

Many studies on PIA systems have already been conducted. Several of these studies to date showed that agents can improve students' learning engagement and motivation. Literature on PIAs revealed that the aspects investigated in these studies can be categorised into three types, namely agents' appearance, facial expressions and behaviours (Derrick and Ligon, 2014; Gulz and Haake, 2006). In terms of agents' appearance, the focus is on how the agent resembles a human being (look, voice, ethnicity, gender, etc.). With regard to agents' facial expressions, various studies have investigated how facial expressions affected users' experiences and performances. Lastly, in terms of agents' behaviours, the focus is on the manner in which the agents communicate their messages to the users. Table 2.5 provides a summary of results of a selection of previous studies that investigated the above-mentioned aspects. The previous studies shown in Table 2.5 are grouped according to the year in which they were undertaken.

Table 2.5: Summary of Previous Studies on PIAs

Year	Researcher(s)	Purpose	N (Sample Size) and Statistical Analysis	Results
2010	Foo (2010)	Compared the effects of two versions of agents (Expert Agent (EXA) and Mentor Agent (MEA)) which had different instructional roles for instructing learners with varying cognitive styles.	N= 86 participants N/A males N/A females ANOVA	Learners facilitated by MEA performed much better than learners facilitated by EXA.
	Sahimi, Zain, Kamar, Samar, Rahman, Majid, Atan, Fook and Luan (2010)	Compared the impact of the degrees of realism of three kinds of agents (Online Learning Cartoon Pedagogical Agents (OLCPA), Online Learning Moderately Realistic Pedagogical Agent (OLMRPA), and Online Learning Highly Realistic Pedagogical Agent (OLHRPA)) on students' achievement during online learning in terms of gender.	N= 130 participants 97 males 33 females ANOVA	Male students' achievements were equal to female students' achievements
	Qiu and Benbasat (2010)	Investigated the effect of the ethnicity matching of agents and users from the users' perceptions.	N= 188 participants 94 males 94 females ANOVA MANCOVA	Positive

2011	Kim and Wei (2011)	Investigated the manner in which the similarity of learner/agent attributes would influence the instructional effectiveness of a pedagogical agent.	N= 210 participants 110 males 100 females Chi-Square ANOVA	Students chose agents having the same gender and ethnicity than themselves. Males who chose agents showed more positive attitudes than those who were assigned to agents. Females who were assigned to agents showed more positive attitudes than those who chose their agents.
	Nunamaker, Derrick, Elkins, Burgoon and Patton (2011)	Investigated if the change of the agent's gender has an effect on users' perceptions.	N= 81 participants 44 males 37 females ANOVA ANCOVA	Positive
	Nunamaker *et al*. (2011)	Compared the effects of a smiling versus neutral agent on user perceptions.	N= 81 participants 44 males 37 females ANOVA ANCOVA	Smiling agents are more likable than neutral agents.
2012	Cheng and Chen (2012)	Investigated the effect of the pedagogical agent in assisting elementary students with high, averages and low math levels, to learn mathematics.	N= 62 students N/A males N/A females T-test	Positive
	Yılmaz and Kılıç-Çakmak (2012)	Investigated the impact of educational interface agents with different attributes (i.e. humanlike, cartoon character, voice only, and no interaction with the agent) on achievement, attitude and retention of elementary school students in their science and technology courses.	N= 70 students from elementary 32 males 38 females ANOVA ANCOVA	The human-like characteristic is more effective in acquiring achievement when compared to the other three attributes (i.e. cartoon character, voice only, and no interaction with the agent).
2013	Johnson, DiDonato and Reisslein (2013)	Examined k-12 students' preferences for four pedagogical agents (young male, young female, old male and old female) and for individual agent characteristics.	N= 565 students from elementary, middle and high school 279 females 286 males Chi-Square	Students preferred agents whose specific external characteristics are close to their own external characteristics.

	Liew, Tan and Jayothisa (2013)	Examined the impact of a peer-like agent (female college student in her 20s) to an expert-like agent (female college lecturer in her 40s) stereotypes on learning outcome and behaviours.	N= 56 business major students 33 females 23 males ANOVA	Learners enjoyed lesson offered by peer-agent more than those offered by an expert-like agent. Learners had high trust in lesson presented by an expert-like agent compared to a peer-like agent. Female learners reported less anxiety in learning tasks with an expert-like agent than with a peer-like agent.
	Lin, Atkinson, Christopherson, Joseph and Harrison (2013)	Investigated the effects of an animated pedagogical agent that provided verbal feedback (simple feedback vs. elaborate) in a multimedia learning environment.	N= 135 undergraduate and graduate students 80 females 55 males ANOVA ANCOVA MANOVA	Participants that used elaborate feedback outperformed those who used simple feedback in terms of scores on a learning measure.
	Schroeder and Adesope (2013)	Compared the effects of learning with either a peer pedagogical agent (agent presence and gestures concurrently with narration in a virtual classroom) or a low verbal redundancy (without agent presence and keywords displayed on-screen concurrently with narration) on learners' cognitive and effective outcome scores.	N= 79 aspiring teachers 59 females 20 males MANOVA	In terms of outcome scores, no statistically significance difference between the groups who used peer pedagogical agents and those who used low verbal redundancy.
2014	Hong, Chen and Lan (2014)	Compared the teaching efficacy of the animated pedagogical agent-based instructional materials and traditional curriculum for elementary students in English education.	N= 63 elementary school students N/A females N/A males T-test	The group that used the animated pedagogical agent-based instructional materials outperformed those who used the traditional curriculum.
	Romero-Hall, Watson and Papelis (2014)	Compared the effects of three versions of multi-media learning environments with an emotionally-expressive animated pedagogical agent, a non-expressive animated agent, and without an agent, on learners' visual attention, emotional responses, learning achievements, perceptions and attitudes toward the learning experience.	N= 66 college students 53 females 13 males ANOVA	Students who interacted with the emotionally-expressive animated pedagogical agent showed higher visual attention to the learning environment and experienced significant effects for the sad and scared emotional states. Participants that interacted with the learning environment without an agent achieved higher post-test scores.

	Sarrafzadeh, Fourie, Kingston, Alexander, Overmyer and Shanbehzadeh (2014)	Investigated the effectiveness (impact) of an effect-sensitive pedagogical agent (EVE) on student performance, motivation and perceptions of the tutoring experience.	N= 62 participants 32 females 30 males ANOVA	Significant overall increase in student scores from pre-test to post-test. EVE assisted students to improve their learning.
	Tegos, Demetriadis and Tsiatsos (2014)	Examined and compared the effects of a MentorChat conversational agent to trigger students' productive dialogue in two kinds of intervention models, namely: undirected interventions (targeted all students in the entire group) and weak-directed interventions (targeted only the weak students)	N= 30 undergraduate students 26 females 4 males T-test	Weak-directed agent interventions were found to be more efficient than undirected interventions by increasing the level of explicit reasoning.
2015	Andrade, Anam, Karanam, Downey and Ruiz (2015)	Investigated whether an avatar-based, online, self-management program is an effective therapeutic approach for women with an overactive bladder (OAB) compared to the face-to-face self-management instruction of the same program (without avatars).	N= 47 patients 47 females 0 males ANOVA ANCOVA	An avatar-based intervention embedded into an online self-management program was significantly better and improved OAB symptoms in women.
	Dincer and Doganay (2015)	Examined the impact of a pedagogical agent on learners' motivation levels and academic success in the context of Computer Assisted Instruction Software (CAIS).	N= 127 secondary school students 56 females 71 males ANOVA	The use of a pedagogical agent had a positive impact on learners' motivation, as well as their academic success.
	Hooshyar, Ahmad, Yousefi, Yusop and Horng (2015)	Investigated the efficacy of Flowchart-based Intelligent Tutoring Systems (FITS) versus not using FITS in improving novice programmers' problem-solving ability.	N= 44 undergraduate students N/A females N/A males ANOVA	The FITS group experienced better improvement in their problem-solving abilities than those who did not use FITS.
	Lee, Kanakogi and Hiraki (2015)	Compared the interaction influences of the temporally contingent Pedagogical Agent with Graze Interaction (PAGI) (live group) and the recorded version of PAGI (recorded group) used for teaching students words of a foreign language.	N= 30 university students 7 females 23 males T-test	The scores of students in the live group were significantly better than those in the recorded group.

	Ramachandiran and Jomhari (2015)	Investigated e-learners perceptions and their Kansei (psychological feeling towards something) experiences towards three different groups of pedagogical virtual agents classified as young, adults and older adults.	N= 105 undergraduate students 38 females 67 males T-test	Higher ratings for pedagogical agents with many similar demographic features than the e-learners were found. Higher positive emotion ratings were found for attractive virtual agents. A positive and significant relationship between the attractiveness of the pedagogical virtual agent and realistic appearance of the agent were also found.
	Shiban, Schelhorn, jobst, Hornlein, Puppe, Pauli and Muhlberger (2015)	Investigated the effect of agent appearance features of three kinds of virtual tutoring agents (male agent, female agent, and no agent) on students' learning motivation and exam performance.	N= 108 psychology students 87 females 21 males T-test	Female agents (rated young and attractive) outperformed male agents (rated old and less attractive) in terms of students' interest in the course material, their motivation and their performance in the exam.
	Yung and Paas (2015)	Investigated the effects of a pedagogical agent giving cues on students' learning performance, cognitive load and instructional efficiency in a story-based instructional animation of the cardiovascular system.	N= 133 seventh-grade students 66 females 67 males ANOVA	A pedagogical agent giving cues had a positive effect on students' learning performance and instructional efficiency. There were no significant differences found in cognitive load between the group of students who used the agent and those who did not.

Initially, Gulz (2004) conducted a review study about claims by previous researchers regarding the benefits of using pedagogical agents. In this particular study Gulz (2004) discovered that PIAs were able to offer the following six benefits:

- Increase motivation;
- Enhance comfort in a learning environment;
- Motivate learning behaviour;
- Improve smoothness of information and communication flow;
- Fulfil personal relationship needs to learning; and
- Offer positive gains on learning achievements in terms of improved memory, problem solving and knowledge transfer.

Nonetheless, claims surrounding results obtained from previous research studies in the field of PIAs have been mixed, sometimes even contradictory. For example, Gulz (2004) above highlighted some benefits offered by PIAs in her study. Additionally, she also noted that the evidence surrounding these claims is at best mixed. Several claims have been made in an attempt to explain the dissimilarity in the results obtained in the studies of PIAs. For example, Bickmore and Cassell (2005) mentioned that lack of evidence and inconsistencies in the studies performed to date may be attributed to methodological shortcomings and variations in the kinds of animations used, the kinds of comparisons made (control conditions), the specific measures used for the dependent variables, and the context of interaction. Other researchers such as Xiao, Stasko and Catrambone (2005) claimed that the difference in the studies' results can be attributed to the lack of key perspectives and a common framework to guide the empirical studies. Likewise, Xiao (2006) acknowledged that research in this area has been hampered by lack of a coherent framework to guide the development of hypotheses, the construction of experiments and the interpretation of results.

Similar to previous studies, this research study also investigated a subset of the different factors affecting user-agent interactions, such as the agent's appearance, voice, movement and gender. However, although previous studies contributed to our understanding of the potential of PIAs to enhance learning, most of them focused on childhood to undergraduate, college-aged adult populations (Carmody and Berge, 2005). As a result, existing literature does not provide much about studies investigating the incorporation of PIAs in adult learning environments, leaving a gap in the literature that needs to be filled, hence the need for further research on this issue. In an attempt to address this issue and to fill that gap, the current research study uses SMOS, which incorporated various kinds of PIAs, to investigate their potential to facilitate adult computer literacy training (Mabanza and De Wet, 2014a; Mabanza and De Wet, 2014b). The novelty of this research study, therefore, lies in the fact that it focuses only on adult computer literacy learners with no formal post-school training, in particular adult computer illiterates in a 3rd world country. In addition, their ages varied, with some not having had access to learning material for many years and being quite rusted in terms of studying. Here, the term *adult computer illiterates* refer to adult learners who never had the opportunity to learn how to use a computer.

In the next section the characteristics of adult learning will be discussed.

2.6 Adult Learning

Adult education is also known as andragogy (Melissa, 2013). The term *adult* can have various meanings depending on the context (i.e. biological, legal, etc.). In the context of this study the term *adult* is used from a legal perspective. Thus, adult refers to a person (man or woman, employed or unemployed) who is fully grown and has the right to participate as a citizen in civil issues as a member of society (Longe and Boateng, 2010). Learning is the process of personal change whereby learners customise new information to make it relevant and meaningful (Dobrovonly, Stevens and Medina, 2007). For the purpose of this study, the researcher defined adult learning as *an extension of educational opportunities to those adult learners with little or no formal education, who feel the need for further training.*

Adult learning is conducted through a diverse range of formal and informal learning activities aimed at educational or training purposes (Hansman and Mott, n.d.; Johnson, n.d.). The educational purpose comprises fundamental training for adults, i.e. giving adult learners opportunities to compensate or make up for their educational failures at a younger age. Examples of educational purpose include completion of primary or secondary education, adult basic education classes, etc. The training purpose comprises acquisition of new or practical skills, which will enable them to improve their lives, rather than pursuing educational study. Some examples of training purposes include apprenticeship programs, work-related courses, vocational training programs, etc. In the context of this study, the key objective of facilitating adult computer literacy implies equipping adult learners with the practical skills that will enable them to perform tasks with computers, thus increasing their employment opportunities. Based on the aforesaid, this study was considered to be aiming at training purposes.

There are many reasons why adult learning differs from the way children's and youngsters' education is conducted (McDonough, 2013). Adults typically perceive learning as a goal, whereas children typically perceive learning as an activity (Dobrovonly *et al*., 2007). Malcolm Knowles, who is the pioneer in the field of andragogy (adult learning), identified the following six principles of adult learners (Barnum, 2002):

- Adults are autonomous and self-directed. They need to be free to direct themselves.

- Adults have accumulated a foundation of life experiences and knowledge that may include work-related activities, family responsibilities and previous education. They need to connect learning to this knowledge/experience base.
- Adults are goal-oriented. Upon enrolling in a course, they usually know the goal they want to attain.
- Adults are relevancy-oriented. They must see a reason for learning something.
- Adults are practical, focusing on the aspects of a lesson most useful to them in their work. They may not be interested in knowledge for its own sake.
- Adults need to be shown respect. Instructors must acknowledge the wealth of experiences that adult participants bring to the classroom.

Melissa (2013) affirmed that Malcolm Knowles's six principles of adult learners serve as the key foundation for designing and effective delivering of adult training. Hansman and Mott, (n.d.) also confirmed that Malcolm Knowles's proposed principles concerning adult learners were widely adopted in the 20th century as helpful in understanding adult learners. For the purpose of this study, these six principles will be adopted as characteristics of adult learners as these principles highlight the distinguishing features of adult learners rather than the rule that has to be followed.

According to a global report on adult learning and education (UNESCO Institute for Lifelong Learning, 2013), the importance of adult learning was being recognised in various countries, governments and educational policy makers globally. As a result, countries around the world have developed national strategies and various programs in order to support adult learning. In most of these countries, adult training programs are often a collaboration between governments, community-based organisations and traditional providers (i.e. universities, colleges). The service providers for this kind of learning include traditional school systems (e.g. primary, secondary and tertiary education institutions), specialised educational institutions for adult learning in local communities, educational centres in companies, voluntary organisations, and private institutions for adult learning. For the purpose of this research study, the focus will be on adult learners in the South African context.

2.6.1 Adult Learning in SA

The South African government has taken several initiatives with regard to the improvement of adult learning. The Adult Basic Education and Training (ABET) programmes are one example of such initiatives. The Kha ri Gude (*let us learn*) program launched in 2008 is one of the most successful ABET initiatives in SA (Department of Basic Education: Republic of South Africa, 2014). Kha ri Gude is a national government programme initiative designed specifically to deal with the mass adult literacy campaign (Kha ri Gude, 2012). This program aimed to, by 2015, train 4.7 million adults above the age of 15 to become literate and numerate in one of the eleven official languages (Department of Basic Education: Republic of South Africa, 2014). In an effort to reach its target, government worked in partnership with non-governmental and private organisations.

Although the SA government has a well-planned strategy to improve literacy among adults, there are still some challenges. Similar to other developing 3rd world countries, SA is also still challenged by adult illiteracy. As mentioned in Chapter 1, a study conducted by Professor Solomon Sibiya from the University of Pretoria revealed that illiteracy among the black population in SA is preventing young people and adults from effectively participating in the social, economic and political life in the new SA (Continental Corporation, 2010). In SA, blacks are the majority and constitute approximately 80.2% of the total SA population (Statistics SA, 2014). There are various causes for illiteracy among adults (especially the black population) in SA. Dagatan (2012) conducted a study to investigate the causes of illiteracy in the world. She identified ten major causes of illiteracy, namely economic conditions, poor implementation of educational programmes, preference to work over education, rate of emigration, individual disability, lack of funds, cultural influences, geographical factors, mind- set about education and population growth. Therefore, it is possible that some of the above-listed causes might also be applicable to the population in SA. Each of these causes will now be explained with the SA context in mind:

- Economic conditions: there is a high level of poverty among the population, especially in rural areas. This is due to many factors, such as the absence of public facilities, lack of basic infrastructure such as access roads, electricity supply, communication infrastructure, and lack of access to education.
- Poor implementation of educational programmes: there are prior existing problems such as apartheid policies that had been the cause of inequalities in the system of education. As

a result, adults (specifically the black population) had no schooling opportunities, particular in the rural areas.

- Preference to work over education: there are a number of reasons why someone would prefer work over education. Some would just choose to work because of the lack of finance to pursue tertiary study. Others go to work for the sake of assisting or looking after either parents (i.e. in the case where parents are old or sick (HIV/ AIDS pandemic)), or siblings (e.g. in the case where parents are deceased). In other cases, people would prefer to work just because they are tired of studying or if they feel intellectually challenged by their studies.
- Rate of rural exodus: there are many people moving from rural areas to urban areas in search of better opportunities. These people are often faced by other realities when they reach the urban area. As a result, they end up living in poor conditions (i.e. shacks) where they still do not have access to basic living conditions such as water, sanitation, electricity or even education.
- Individual disability: some people have a physical and/or mental impairment that substantially restrict them to fully participate in one or more major life activities (i.e. follow a normal school routine). To avoid marginalising this group of individuals in society, they need to attend specialised schools that can cater for their needs. However, in reality these schools often are difficult to identify, too expensive, or limited in numbers. Another challenge is that these schools usually can accommodate a limited number of learners only.
- Lack of funds: often the government educational budget is insufficient to cover basic educational needs. Consequently, not everyone has access to the funds. In addition, these situations often make it difficult to meet other educational targets to initiate new projects, such as erecting new school buildings in remote areas or improving the quality of existing ones, especially in the rural areas.
- Cultural influences: in rural areas women are still considered as responsible for managing the households and looking after the children at home. As a result women are not prioritised when it comes to education matters. Parents play a primary role in teaching the value of education to their children. Therefore, it is also their duty to encourage study habits at home. However, this sometimes becomes quite a challenge if the parents are illiterate as well.

- Geographical factors: the challenging geographical conditions of some rural areas, such as mountains, lack of roads and long distances between villages, make it difficult for people who live in such areas to pursue education. As a result, inhabitants sometimes have to walk very long distances to access schools, causing a lack of school attendance in such areas.
- Mind-set about education: different people have different beliefs about the role of education in their lives. There are some people still thinking that education will not add any value to their lives. The cause of this might be a religious belief, a cultural issue, or viewpoints from their parents or other people around them.
- Population growth: the increase in the population has also affected the budget for education. Although there is a good policy on free education, because of the growing population, the budget is not adequate to cover all educational needs.

Based on this discussion, it is evident that the problem of adult illiteracy could pose a serious challenge to the social and economic development in SA.

The World Literacy Foundation (2015) conducted a study to investigate the cost of illiteracy in countries around the world. Their findings revealed that illiteracy among populations are costing the economies of countries around the world billions of American dollars. Table 2.6 below provides comparative figures on the cost of illiteracy in various emerging countries.

Table 2.6: Cost of Illiteracy in Emerging Countries (World Literacy Foundation, 2015)

Country	Annual GDP In $ (billions)	Annual Cost of Illiteracy $ (billions)
Argentina	563.138	6.757656
Brazil	1,903.93	22.847208
Chile	250.472	3.005664
China	11,211.93	134.543136
Colombia	332.384	3.988608
Egypt	286.435	3.43722
India	2,308.02	27.696216
Indonesia	895.677	10.748124

Iran	393.495	4.72194
Lebanon	54.671	0.656.52
Malaysia	327.89	3.93468
Mexico	1,231.98	14.783784
Morocco	102.044	1.224528
Nigeria	515.431	6.185172
Pakistan	250.136	3.001632
Peru	190.268	2.283216
Philippines	308.033	3.696396
Russia	1,176.00	14.111952
South Africa	**323.809**	**3.885708**
Thailand	386.291	4.635492
Taiwan	527.773	6.333276
Turkey	752.51	9.03012
Vietnam	204.493	2.453916
TOTAL	**24496.808**	**293.961696**

Referring to Table 2.6, the Gross Domestic Product (GDP) refers to the total monetary value of all final goods and services produced in a country in a given year (InvestorWords, 2015). The American dollar monetary values in Table 2.6 represent the 2015 estimated annual calculated GDP and cost of illiteracy for some emerging countries.

Many people refer to SA as a 3rd world country, but literature reveals that SA is classified as one of these emerging countries. According to the figures displayed in Table 2.5, SA had a GDP of $ 323.809 billion (i.e. approximately R 5 trillion) in 2015, while the cost of illiteracy in the same year was estimated at $ 3.8857086 billion (i.e. approximately R 57 billion).

Illiteracy has also been identified as one the factors influencing the high level of technological ignorance among the population of SA. We are currently living in a technological era in which there is a growing dependency on technology. Therefore, it is necessary that people should be encouraged to become technologically literate in order to

effectively engage and function in a technological dependent society. In SA (as in other countries in the world) computers have become an integral part of people's lives. This implies that when people perform their daily social activities (i.e. learning, social communication, interacting with government agencies, banking, shopping, etc.) they interact or use computers in one way or another. Likewise, computer skills have become one of the major requirements to enter the job market. This situation poses lots of challenges for illiterate people in SA because their levels of illiteracy limit their abilities to effectively engage and function in a technological dependent society.

Taking into account the aforementioned set of challenges, it is clear that there is a need to find better ways to support technological illiterate people in SA so that they can become part of the workforce and gain self-confidence (Mabanza and De Wet, 2014a; Mabanza and De Wet, 2014b). This could also enable them to be included in labour and social activities. This can be achieved by giving them the necessary learning opportunities, such as basic computer training, which can promote their skills development for employability and improve their lives in general.

As pointed out earlier, the focal point in this research study will be on adult learners in the context of SA. Emphasis will specifically be on adult computer literacy training, which will be discussed next.

2.6.1.1 Adult Computer Literacy Training in SA

In general, the term *computer literate* describes a person who has sufficient knowledge and skill about the use of computers (Collins Dictionary, 2013). Accordingly, training involves developing a set of skills necessary for specific tasks or responsibilities and, therefore, is for immediate application and often of limited scope (Ketelhut and Niemi, 2007). In relation to the afore-mentioned, one can say that the key objective of adult computer literacy training is to assist adult learners to acquire basic knowledge and a set of skills necessary to use computers for performing basic tasks.

- **Computer Training Approaches**

In SA to date, as in other developing countries, adult computer literacy training has generally been conducted using approaches such as conventional training and e-learning.

Conventional Training

Conventional training is conducted face-to-face by a skilled human instructor. This approach is viewed as a one-to-many teaching approach that involves one skilled human instructor conducting the training session for a group of trainees (Franzoni and Assar, 2009).

There are two main groups in the training environment, namely the trainees and the instructor. Each of the two parties has a specific role to assume. The roles of trainees are to gain knowledge and skills. The roles of instructors are to help trainees personalise new information (Dobrovonly *et al*., 2007), and to guide, tutor and encourage trainees. Furthermore, trainees might have some expectations with regard to the instructor. For example, when they are faced with a difficult situation during their training activities, the trainees are confident that the instructor has the competence to help them to successfully solve challenges. The extent to which trainees rely on the instructor's input is crucial to the success of the training. Likewise, trainees also have responsibilities in order to achieve this success: they must show some level of commitment and enthusiasm about what has been taught by the instructor.

In these conventional computer training environments, some kind of reliance exists in the relationship between the instructor and the trainees. However, individuals generally learn at a different pace – a fact that this one-to-many relationship does not specifically cater for.

E-learning

Clark and Mayer (2011: 8) defined e-learning as instruction delivered on a digital device, such as a computer or mobile device that is intended to support learning. To improve learning experiences, an e-learning platform includes text, graphical-based information and animated examples with an option of sound. Referring to the definition, in the context of this study, the focus in terms of a digital device would be on a computer. E-learning can be considered as an alternative to a conventional computer training approach. One of its main characteristics is the use of technology, such as the Internet, to facilitate the learning process. Since e-learning has often used the Internet as its backbone, there is a need for a human being who has the skills to operate and manage the infrastructure required for deploying an e-learning platform. Yet, such a human being's intervention in an e-learning platform is less compared to conventional computer training. Existing literature reviews on e-learning revealed that many educational and training settings are using e-learning platforms to provide computer literacy

training. The Siyakhula Living Lab is one such example where e-learning is used to deliver basic computer literacy training to the marginalised rural community of Dwesa in the Eastern Cape Province, SA (Gumbo, Thinyane, Thinyane, Terzoli and Hansen, 2012).

From the explanations above it seems that the conventional and e-learning approaches could pose intellectual challenges to certain kinds of trainees. In the context of this study, adult computer illiterate trainees would fall into this category. These challenges could be caused by factors such as the lack of self-esteem and confidence, mostly due to the lack of basic education at a younger age, never having been exposed to a computer before, or even just doubting their ability to use a computer (Mabanza and De Wet, 2014a; Mabanza and De Wet, 2014b). These trainees often need special attention, such as one-to-one tutoring, in order for them to better understand and actually gain knowledge and acquire skills during the computer literacy training process. In reality, it is practically impossible for the skilled human instructor to provide special attention of this kind to each and every trainee during a training session.

Furthermore, due to challenging geographical conditions that make it difficult for instructors to reach people in need of training in rural areas, there is a shortage of skilled human instructors in some areas. These challenging geographical conditions in some rural areas pose difficulties and severe cost implications when attempting to deploy Internet-based e-learning platforms. Additional challenges that could hamper e-learning are the lack of basic computer skills to use the Internet effectively, obtaining skilled human beings to maintain the e-learning platforms, and the unaffordability of accessing the Internet, especially in rural areas where people are living in poverty.

As mentioned in Section 2.6, because adult learners have particular characteristics (i.e. six principles of adult learners) their training needs to differ from conventional training methods (Brookfield, 1998). Hence, in order to meet their training needs, it is vital that the instructor understands these characteristics and finds a way to create a training environment that implements them. Bearing this set of challenges in mind, it seems as if very little has been done to find ways to facilitate computer training for these kinds of trainees (Mabanza and De Wet, 2014a). Coming up with ways to facilitate computer training for them should improve their computer training experiences, and could also allow reaching more people who are facing the same dilemma. In order to achieve this, and to ensure that the training is structured

around their needs, it is crucial for any training provider to understand these challenges and the adult learners' characteristics (Johnson, n.d.). Therefore, education providers need to develop innovative solutions for reaching larger numbers of those less familiar with technology (both young and older adults) (Githens, 2007), otherwise these individuals will become even further marginalised.

Training with PIAs

Training with PIAs involves using agents to conduct the training instead of a skilled human instructor. In this approach, the agent interacts directly with the trainee and guides him/her on how to perform a task. As a result, there is a lack of human intervention.

Research is being conducted into using tools such as PIAs, which are able to adapt their level of support in order to meet a user's preferences, needs or situation (Sayers, McKevitt and McTear, 2009). Atan *et al*. (2008), Bowman (2012), Mao and Li (2010), and Morozov, Tanakov and Bystrov (2004) further advocated that PIAs have the ability to provide individualised instruction that is tailor-based on the learners' ability to learn, rate of learning, and learning needs. Bowman (2012) pointed out that PIAs are available at all times, hence giving a learner the opportunity to have unlimited access to his or her own *instructor*. Atan *et al*. (2008) claimed that PIAs can cater for unlimited numbers of learners. As it is, PIAs can be designed to perform a human instructional role, as well as communicate with the learners in natural language, to guide them in order to have a better experience of the learning material (Atan, *et al*., 2008; Landowska, 2008). In line with this, Wonisch and Cooper (2002) suggested that the educational multimedia and computer-based training industries look towards PIAs as a promising solution to the challenges of modern educational environments. PIAs are powerful tools that can also affect learners in many ways, even emotionally. Emotions can be a barrier to learning. This is especially true for adults, who bring a wealth of experience to the instructional environment (Carmody and Berge, 2005). On the other hand, Shneiderman and Plaisant (2010) are of the opinion that PIAs can increase anxiety and decrease performance of adults. They also advise that great caution should be exercised when PIAs are used in the context of an adult user population. In line with this, Strafling, Fleischer, Polzer, Leutner and Kramer (2010) asserted that the inclusion of PIAs can be beneficial to adult learners, provided that appropriate criteria of the agents are applied. Others researchers, such as Haake and Gultz (2008), Theodoidou (2011), and Veletsianos (2010), also pointed

out that the agent's given observable characteristics have an impact on the manner in which some learners relate to that particular agent.

The current research is an effort to investigate whether the incorporation of PIAs into adult computer literacy training can overcome problems faced by adult computer illiterates during conventional training, and if the use of PIAs can improve these persons' computer performance (Mabanza and De Wet, 2014a; Mabanza and De Wet, 2014b). This research was conducted with the co-operation of a group of adult learners from MUCPP based in Bloemfontein, SA. These adults had little or no formal post-school education and were literate in terms of being able to read and write. They had little or no previous exposure to computers and limited computer learning experiences. Their ages varied, with some not having had access to learning material for many years.

It is to be expected that computer literacy training that involves user-computer interaction where a mouse, keyboard and typing are necessities, presents an additional set of challenges for these adult learners, adding to their anxiety and nervousness. Therefore, these facts were taken into consideration by the researcher when he had to decide how the computer literacy training sessions would best be conducted. The major challenge was finding the best approach for simplifying the training for all these adult learners from MUCPP without compromising the quality of their training. In an attempt to simplify the training process for them, the decision was made to use SMOS, developed by Potgieter (2010) at the University of the Free State. SMOS has similar (but limited) features to MS Word and incorporated a variety of PIAs (varying in terms of appearance, gender, voice and reality). As mentioned earlier, PIAs can affect learners in many ways, including on an emotional level. Bearing this in mind, it was deemed possible that adult learners from MUCPP might react differently to various types of PIAs incorporated in SMOS.

In order to determine the best approach, best techniques or best aesthetics in software applications, products (i.e. a particular computer system) should undergo usability evaluation to investigate their usability. In this research study, a variety of PIAs incorporated in SMOS needed to be evaluated in order to assess the extent to which each of these PIAs could assist adult learners in acquiring skills to perform tasks with a word processor similar to MS Word.

The next section will provide a more detailed discussion on usability and usability evaluation.

2.7 Usability

There are many proposed definitions for usability. A few of the well-known definitions are listed in Table 2.7:

Table 2.7: Definitions of Usability

Source(s)	Definition
ISO/IEC 9126-1 (2001)	The ease with which a user can learn to operate, prepare inputs for and interpret outputs of a system or component.
ISO 9241-11 (1998)	The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.
Nielsen (2012)	Usability is a quality attribute that assesses how easy user interfaces are to use.
Usability.gov (n.d.)	Usability refers to how well users can learn and use a product to achieve their goals and how satisfied they are with that process.

All the proposed definitions listed in Table 2.7 focus on the usefulness of a system to support the user in accomplishing his/her goals. The variations among these definitions are the result of the kinds of usability attributes that are used to determine the system's usefulness. There are different kinds of systems; depending on the type of system being evaluated one usability attribute might be more critical than another. As a result, experts have different opinions about which criteria, or the kind of usability attributes, should be used to judge the usefulness of a particular system. This has led to the existence of many kinds of usability attributes (Nielsen, 2012; Peute, Spithoven, Bakker and Jaspers, 2008). For example, the proposed International Organisation for Standardisation (ISO 9241-11) definition highlighted effectiveness, efficiency and satisfaction as main usability attributes for determining the system's usefulness. MacDonald (2012) and Peppa, Lysikatos and Metaxas (2012) further emphasised that any usability evaluation attempt to evaluate a system has to be done according to at least these three usability measurement indicators proposed by ISO 9241-11. There is no clear consensus within the research community about the number of usability attributes that should be taken into account when determining a particular system's usefulness. As a result researchers have, with time, identified and implemented other usability attributes. Some of them are identical to the three basics ones already mentioned; others have added additional attributes to complement these three (i.e. ISO 9241-11). For example, Nielsen (2012) added learnability, memorability and errors; Shneiderman (1998) added time to learn, retention over time and rate of errors by users; Dix, Finlay, Abowd and

Baele (2004) proposed learnability, flexibility and robustness, whereas Hornbaek (2006) suggested a list of usability indicators and also proposed how these could be measured. Although researchers have proposed numerous usability attributes, the key focus of usability is about the usefulness of a system to support the users in achieving their goals.

For the purpose of this study, the proposed definition by ISO 9241-11 (1998) was adopted. As mentioned before, ISO 9241-11 (1998) defined usability as *the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.*

Therefore, in applying the adopted definition to the context of this research study, the term *specified users* refers to adult computer illiterate learners, and the term *specified goals* refers to performing various given word processing tasks successfully. Lastly, the term *particular environment* referred to the SMOS environment that adult computer illiterate learners will use to perform word processor tasks (with the aid of PIAs) for the purpose of usability tests.

The adopted definition highlighted three important usability attributes, namely *effectiveness, efficiency* and *satisfaction*, which also form the focal point in this research study. The meaning and the manner in which each of them will be measured is explained in Table 2.8.

Table 2.8: Meaning of Usability Attributes

Attributes	Description	Meaning in the context of SMOS
Effectiveness	How easy is it for users to accomplish basic tasks the first time they encounter the design?	The capability of PIAs incorporated in SMOS to enable adult computer illiterate learners to achieve specified word processor tasks with exactness and in totality.
Efficiency	How fast can experienced users accomplish tasks?	The ability of PIAs incorporated in SMOS to enable adult computer illiterate learners to expend less amounts of effort in completing their word processor tasks.
Satisfaction	How much does the user like using the system?	The adult computer illiterate learners' comfort to use PIAs incorporated in SMOS.

All the usability attributes listed above will be evaluated by means of usability evaluation with the aim of determining the usability of the 10 PIAs incorporated in SMOS.

2.7.1 Usability Evaluation

Zhang and Basili (1996) pointed out that usability evaluation is also called usability assessment. The researcher is aware that these two terms can be used interchangeably. However, in the context of the current study, the researcher opted to use the term *usability evaluation*, because it is most commonly used within the research community. Evaluation is *the process of gathering data about a prototype system or a deployed system's functionality, as well as its ease of use and learnability* (Preece *et al*., 2011). Gathered data can then be used for evaluating if the system meets specific goals of the usability. According to Tullis and Albert (2008), the goals of usability evaluation can be formative or summative. These two differ in terms of their evaluation objective. Formative usability evaluation or user-centered evaluation (Scriven, 1967) takes place during the system or prototype's design or development stage. Its main purpose is to collect information that can help improve the design of the prototype or the system. Summative or comparative usability evaluation (Bowman, Gabbard and Hix, 2002) is performed to assess the efficacy of a completed prototype system or a deployed system. Its key objective is to assess how well a prototype system or a deployed system meets the intended requirement or expectations. El-Halees (2014) used the terms *subjective* and *objective* usability evaluation to refer to formative and summative usability evaluation respectively. Summative usability evaluation was used in this research study.

It is well known in the research community that different approaches to usability evaluation have been proposed. For example, Barnum (2002) and Tsai (n.d.) stated that usability evaluation can be done either in laboratories (in-vitro), or can be carried out in the field (in-situ). In addition, Sauro (2012) identified three ways of running usability tests, namely lab-based, remote moderated, and remote unmoderated. Also, Preece *et al*. (2011) identified three main evaluation paradigms: usability testing, field studies and analytical evaluation. Although these authors used different terms, the terms all have the same meaning because they all refer to the manner of performing the usability evaluation of a system. In the context of this study, the researcher chose to use the term *approaches*. The reason for this is to avoid confusion with the *research paradigms* that will be discussed in Chapter 3. A literature search on usability evaluation approaches revealed that the three evaluation approaches by Preece *et al*. (2011) are the most used. Therefore, these approaches were also adopted in the context of this

study. Each of these usability approaches has different types of usability evaluation methods associated with them (Preece *et al*., 2011), which will be discussed in the following section.

2.7.1.1 Usability Evaluation Methods (UEMs)

UEMs refer to various methods/techniques used at any stage of the system development life cycle for uncovering different usability problems that the system may have (Hub and Capkova, 2009). Over the years, several kinds of UEMs have been proposed. This has also given rise to a number of proposed classifications of UEMs. For example, Whitefield, Wilson and Dowell (1991), as cited by Fitzpatrick (1998), classified UEMs as analytic methods, observational methods, specialists' reports and user reports. In addition, Freiberg and Baumeister (2008) suggested a three-way classification: user-based evaluation, expert evaluation and hybrid approaches. Also, Carvalho (2002), as cited by El-Halees (2014), categorised UEMs into expert evaluation, observational evaluation, experimental evaluation and surveys.

However, a systematic literature review on the classification of UEMs revealed that several researchers used three generic categories when classifying UEMs, namely inspection methods, inquiry methods and user testing methods (Dubey, Rana and Mridu, 2012; Gulati and Dubey, 2012; Partala and Kangaskorte, 2009; Peppa *et al*., 2012). Hence, in the context of this study, the researcher used these three generic categories of UEMs. These categories differ depending on the role of the participants (i.e. usability experts or end-users) involved in the evaluation process, and on the manner in which feedback are collected from the participants. The different kinds of inspection, inquiry and user testing methods will now be discussed. Although not all of these methods were used in the research study, they are presented here in order to see the big picture.

- **Inspection Methods**

Inspection methods are also known as analytical methods (Vukovac, Kirinic and Klicek, 2010), expert-based methods (Hub and Capkova, 2009), or expert-based usability evaluation (Zhang and Basili, 1996). The inspection methods are performed by usability experts without the participation of users. It involves a group of at least two usability experts inspecting usability-related issues of a system by checking its conformity to a set of established usability guidelines. Experts often use their judgment to suggest solutions for the usability problems they identify in a system. Hence in this method, usability experts' judgment, training,

expertise skills, and experience are of the utmost importance. Two kinds of inspection methods, namely heuristic evaluation and cognitive walkthroughs, appear to be the most commonly used (Hub and Capkova, 2009; Madan and Dubey, 2012). Each of these will now be briefly discussed.

Heuristic Evaluation

Heuristic evaluation is an inspection method where a group of usability experts inspect the system and judge its compliance by means of comparing it against a small set of recognised usability principles (Dix *et al*., 2004; Nielsen, 1994; Preece *et al*., 2011). During the heuristic evaluation process, every member of the expert group independently examines and evaluates the system using a list containing design guidelines. Furthermore, they are only allowed to interact with one another once all of them have completed the evaluation process and results are aggregated (Dix *et al*., 2004; Nielsen 1995). In heuristic evaluation the emphasis is on how well the system conforms to the given guidelines.

Cognitive Walkthrough

A cognitive walkthrough is an inspection method where a team of experts assess the design of a system on how well it supports the user in learning a task (Cockton, Lavery and Woolrych, 2008; Dix *et al*., 2004; Preece *et al*., 2011). Cognitive walkthrough evaluation is based on a cognitive model of learning and use; furthermore, the experts should possess cognitive theory skills (Wharton, Rieman Lewis and Polson, 1994). In a cognitive walkthrough the emphasis is on the tasks the users are to perform. Therefore, during walkthrough inspections, experts evaluate each step necessary to perform a task. This is done with the objective of discovering system design errors that would obstruct learning by exploration.

Inspection methods were not used in this study because the focus was on the intended adult users of the SMOS rather than on usability experts.

Inquiry Methods

Inquiry methods refer to the various methods that usability evaluators use to obtain information about users' subjective perceptions of the system and their interaction with it. Interviews, questionnaires and observations are examples of the most popular methods of inquiry (Nektarios, Stravrinoudis, Sokoli and Xenos, 2010; Partala and Kangaskorte, 2009). Each of the named methods of inquiry will now be discussed.

Interviews

An interview is a face-to-face social interaction meeting between the evaluator (e.g. researcher) and the interviewee (e.g. user). It can include both open-ended and closed-ended questions. An interview's general purpose consists of eliciting an individual or a group's opinions, experiences and beliefs regarding a situation of interest. It can also be used for the purpose of gathering supplementary information that may not have been obtained by other methods such as observation or surveys (Cohen, Manion and Morrison, 2011; Shaughnessy, 2007). There are four different kinds of interview techniques, namely unstructured, structured, semi-structured and focus group interviews (Fontana and Frey, 1994). Each of these will now be discussed.

- Unstructured interview: an interview that does not require a set of predefined questions. During the interview, the evaluator poses open-ended questions that give the interviewee an opportunity to express him/her freely using his/her own words or thoughts. For this reason, Preece *et al*. (2011) suggested that when conducting this type of interview, the evaluator must have a plan of the main topics to be covered during the interview.
- Structured interviews: the evaluator uses closed-ended questions. When using closed-ended questions, the evaluator provides the interviewee with a set of possible answers to choose from in order to answer the questions. During the interview, the evaluator follows a predetermined set of questions while interacting with the interviewee. Additionally, the evaluator asks all interviewees the same questions and these questions need to be asked in the same order as well (Preece *et al*., 2011).
- Semi-structured interviews: this technique combines both structured and unstructured interviews and it is less strict than a structured interview. As a result the evaluator uses both open and closed-ended questions. In a semi-structured interview, the evaluator usually starts by asking a series of closed-ended questions followed by open-ended questions based on the interviewee's response.
- Focus group interviews: Fontana and Frey (1994) pointed out that group interviews can be implemented in structured, semi-structured or unstructured format. A focus group is a form of group interview in which the evaluator interacts with a small group of target users. Throughout the group interaction, the evaluator plays the role of a facilitator that leads the group discussion.

Questionnaires

A questionnaire is an organised list of written questions designed to extract specific information from respondents (Businessdictionary, 2011). There is no strict rule in terms of how many questions should be included in a questionnaire, but it should be designed in a manner that allows the evaluator to collect as much data as possible from the target respondents. In general, questions included in a questionnaire seek to collect various kinds of data, such as information on respondents' backgrounds, behaviours, attitudes, opinions, preferences, intentions and expectations about a system of interest. Therefore, it is important that questions be structured and clearly worded so that respondents can easily understand, interpret and complete the questionnaire. This is important especially when the evaluator is not present to clarify confusing or unclear questions (Preece *et al*., 2011).

Questionnaires can use both open-ended and closed-ended questions to collect data. Open-ended and closed-ended questions were already mentioned and explained when interviews were discussed. Open-ended questions provide qualitative data (Waddington, 2000), whereas closed-ended questions provide quantitative data (Waddington, 2000). There are five basic types of closed-ended questions, namely multiple-choice, categorical, ordinal, numerical and Likert-scale questions (Waddington, 2000):

- Multiple-choice questions: presenting respondents with a list of possible answers as options from which they have to select the best one.
- Categorical questions: grouping answers into some sort of category or multiple categories, and respondents are requested to select the category that best suits their answers.
- Ordinal questions: respondents rank their responses based on some predetermined level of measurement.
- Numerical questions: respondents have to provide a numerical answer.
- Likert-scale questions: measure respondents' attitudes or opinions about a statement.

Another common type of rating scale is called the semantic differential scale where respondents are asked to evaluate an object or a concept by means of a set of bipolar contrasting adjectives (Tullis and Albert, 2008).

Questionnaires can be used either alone or in combination with other UEMs to enhance understanding (Dumas, 2003; Preece *et al*., 2011).

Observations

According to PhDStudent.com (2014), observation is a data gathering method in which the evaluator examines a situation of interest and records the relevant facts, actions and behaviours of the participants. The evaluator can decide to observe the situation of interest at any stage during product development (e.g. early stage of design or later in development). If this is done in early stages of design, it assists the evaluator in understanding the tasks. In case this is done later in the development process, it assists in evaluating the usability of the system in supporting users' tasks. Observing the users while they are interacting with the system allows the evaluator to discover things the users may be unaware of or that they will not be able to mention in an interview. In this study, participants were observed while they were using their respective systems to perform word processor tasks.

- **User Testing**

User testing is also called user-based evaluation or usability testing (Zhang and Basili, 1996). Tsai (n.d.) used the terms *laboratory usability testing*, or *empirical usability testing* when referring to user testing. The researcher is of the opinion that, although authors used different terms, all these terms basically have the same meaning. In the context of this study, the term *user testing* is used, which seems to be the most commonly used term.

Unlike inspection methods, user testing involves users' direct participation. In user testing, the end-users are asked to individually complete one or a set of tasks using the system or a prototype system in a controlled environment (Nektarios *et al*., 2010; Partala and Kangaskorte, 2009; Zhang and Basili, 1996). Rubin (1994) pointed out that the overall goal of user testing is to identify and rectify usability deficiencies. User testing can be carried out throughout the system development life cycle (Nielsen, 1993; Preece *et al*., 2011) and is associated with several data collection techniques.

Techniques for User Testing

As mentioned above, there are several data collection techniques that can be used to conduct user testing. The testing procedures and the intended outcome of testing are the two main factors that differentiate these techniques. Testing procedure refers to the manner in which

the test is conducted, whereas intended outcome of testing refers to the possible end result of the testing process.

Some examples of techniques used to collect data during a user test include the think-aloud protocol, co-discovery or co-participation, question-asking protocol, performance measurement, teaching methods and remote testing (Dubey *et al*., 2012; Gulati and Dubey, 2012). Each of these will now be discussed:

- Think-aloud Protocol: this protocol requires users to keep on verbally reporting their thoughts, feelings and ideas while carrying out tasks on the system being evaluated (Dumas and Redish, 1994). This technique enables the evaluators to gain insight into users' cognitive processes while interacting with the evaluated system, thus assisting evaluators to better interpret the reasons behind users' actions. There are two ways in which think-aloud can be performed, namely concurrent and retrospective (Nielsen 1993). Concurrent think-aloud involves users verbalising their thoughts while performing tasks on the system. Retrospective think-aloud involves participants to first work with the system silently after which they can verbalise their thoughts in retrospect by reviewing the videotape of the usability test session.
- Co-discovery or Co-participation: unlike standard thinking aloud tests that involve single users, co-discovery involves two users attempting to work together on the same task using the system being evaluated (Dumas and Redish, 1994; Nielsen, 1993). While they are interacting with the system they are also encouraged to verbally express all their thoughts and evaluators observe their interactions.
- Coaching Method: in the coaching method, the evaluators play the expert/coach role and answer any questions related to the system asked by users (Nielsen, 1993). The coaching method seeks to collect information about the users' needs in order to improve or provide adequate documentation (Gulati and Dubey, 2012; Dubey *et al*., 2012)
- Question-asking Protocol: the evaluator questions the users about the system being evaluated (Dumas and Redish, 1994). The capability of users to answer questions will assist the evaluator to gain a better understanding of which parts of the system are better understood than others (Dubey *et al*., 2012).
- Performance Measurement: this involves capturing data about users' performance while they are using the evaluated system to perform some predetermined tasks (Nielsen, 1993; Spool, Scanlon, Schroeder, Snyder and DeAngelo 1997). While users perform tasks there

is no interaction between the evaluator and the users, hence this kind of user testing is mainly conducted in a controlled environment where the conditions favour accurate data collection and minimise interference. This technique can be used in conjunction with other methods (i.e. observation, interview, questionnaires) to capture qualitative data as well.

- Teaching Methods: teaching method is used as an alternative to the concurrent think-aloud method for usability testing (Dubey *et al*., 2012). Usually, the users are exposed to the system to familiarise themselves with it and to develop expertise in using the system. Afterwards, a user is asked to teach a novice user how to use the system. During the teaching process users do problem solving, explain to the novice user how the system works, and demonstrates a set of predetermined tasks.
- Remote Testing: the evaluator and the users are not physically in the same location during the test. This test arrangement is such that the evaluator can communicate with the user in real time on the user's own computer (Dubey *et al*., 2012). It is also possible that the evaluator can install software on the user's computer to collect data automatically.

Although the various user testing techniques discussed above differ in terms of their data collection techniques, they all attempt to measure the usability quality of the system.

User Testing Metrics

User testing metrics refer to various types of measurable data collected while the users are working with the system or a prototype of the system being tested. Tullis and Albert (2008) pointed out that usability metrics can be classified as performance metrics, self-reported metrics (user perceptions), and behavioural and physiological metrics. Referring to these three types of metrics, literature reveals that performance metrics and behavioural and physiological metrics are usually associated with quantitative measurements in user testing. On the other hand, self-reported metrics (user perceptions) can be considered to be qualitative measurements in user testing. For example, Whiteside, Bennett and Holtzbalt (1988), as cited by Dix *et al*. (2004), along with other researchers such as Barnum (2002), Nielsen (1993), Tullis and Albert (2008), identified the following as the most typical performance metrics for determining quantitative measurements in user testing:

- Time taken to complete a specific task.
- Number and type of errors the user made per task.
- Number of tasks the user completed, without assistance, including after assistance.

- Number of tasks the user did not attempt.
- Time spent by the user to recover from errors.
- The number of tasks the user completed within a given time frame.
- The number of system features that were utilised or not utilised by the user.
- Number of users making a particular error.
- Number of actions or steps taken by the user to complete a task.
- Number of users completing a task successfully.
- Number of times the user used manuals or the *help* system to solve the problem.

Besides the traditional performance metrics listed above, behavioural and physiological metrics (i.e. facial expressions, eye-tracking, pupillary response, skin conductance and heart rate) can also be used to determine quantitative measurements. Specialised equipment (i.e. Facial EMG, eye-tracking monitor, the Galvactivator, EMFI chair, EREC system) is required to monitor and collect behavioural and physiological metrics (Tullis and Albert, 2008).

In addition to the quantitative measurements (i.e. performance metrics, and behavioural and physiological metrics), qualitative measurements (i.e. self-reported metrics or user perception) can also be collected during user testing. Qualitative metrics mainly refer to data collected about users, such as their satisfaction, expectations, and subjective opinions about the system being evaluated. These qualitative measurements are usually collected by means of questionnaires (i.e. pre-test and post-test questionnaires), observation and interviews.

Both quantitative and qualitative metrics are considered to be gauges for determining the quantitative and qualitative measurements of usability attributes (i.e. effectiveness, efficiency and satisfaction) discussed earlier in Section 2.7. Literature revealed that there are many kinds of quantitative and qualitative metrics that can be collected during user testing. Hence, it is always best practice to choose a minimum number of metrics (i.e. quantitative metrics, qualitative metrics, or both) that can reveal the maximum amount of usability detail for the system being investigated.

User testing always involves some kind of planning in order to determine the steps that need to be taken during user testing.

User Test Plan

The test plan forms the core of the entire user testing procedure because it describes step by step directives on how the user testing should be conducted. Therefore, it is crucial to do proper planning before commencing the user testing. Dix *et al*. (2004), Nielsen (1993) and Rubin (1994) pointed out that a user test plan has to address the following issues:

- Define the Test Objectives

  Defining the test objectives consist of clearly stating the following:

  - The reason(s) for performing the test (i.e. improving of the usability of a system, benchmarking users' performance, assessing users' experiences of the system);
  - The kind of usability test that needs to be performed (formative or summative); and
  - The kind of data or metrics that must be gathered in order to achieve the test objectives.

- The Targeted User Profile

  The user testing participants should be as representative as possible of the targeted users of the system. Therefore, it is important to start by first establishing the profile of the target users, their age group, their educational background, and their proficiency regarding the system being tested (Rubin, 1994; Preece *et al*., 2011).

- Method of the Test

  There are two basic methodological designs that an evaluator can use to conduct the user testing, namely between-subject and within-subject (Tullis and Albert, 2008). Within-subject testing is also called *within-subject design*. It is an experimental design that requires that the same group of test participants be tested under each of the test conditions (Cairns and Cox, 2008: 4). As a result, for each participant, all the kinds of measurements taken under one condition are also repeated under the other conditions. Within-subject testing is also referred to as *repeated-measures*. Since within-subject testing uses the same group of participants, the focus here is to examine differences among the subjects.

  Between-subject testing is also referred to as *between-subject design*. It involves using different groups of test participants for different test conditions (Cairns and Cox, 2008: 5; Lazar, Feng and Hochheiser, 2008: 46). The different groups of participants are often referred to as test groups and control groups. These two groups are made up of different people and as a result, during the tests each group of participants (i.e. test and control

groups) are assigned to one test condition only. In between-subject testing, the main objective is to determine if there are any differences between the groups.

- Task List

  The evaluator needs to prepare a task list that consists of selected tasks that the targeted potential users need to perform using the system being tested. Those selected tasks must represent actual tasks (Dumas and Fox, 2008; Rubin, 1994). The evaluator should also provide users with a detailed description as to what actions or behaviours are required for each successful task (Rubin, 1994). Task scenarios need to be an example of real-life scenarios.

- Test Environment, Schedule, Equipment Requirements and Evaluator Role

  User testing should be conducted in a relatively quiet and comfortable environment. The date and time when the testing sessions will take place need also to be specified. The evaluator should identify the type of equipment (desktop, laptop, etc.), as well as software, that will be used in the test. The test environment and equipment need to be checked in terms of their appropriateness in collecting the required data.

  Every party involved in the user testing has a specific role to play. Hence, the role of the evaluator also needs to be specified before the user testing takes place, including when and under which circumstances he/she can intervene during the test.

- Kind of Data to be Collected and the Analysis Process

  As already explained, quantitative and qualitative metrics are the two kinds of data that can be captured during user testing. Quantitative metrics indicate the quantitative data and qualitative metrics designate the qualitative data. In the former case, data is captured about user performance (i.e. time taken to complete a task, number of errors made) while working on pre-defined tasks. In the latter case, data related to users' satisfaction, their opinions and their preferences about the system are collected by means of questionnaires or interviews. As mentioned earlier, generally, the objectives of the test determine the choice of metrics that will be captured during user testing.

Sampling

A sample is considered representative of the population from which it is selected. The population, in statistical terms, is defined by Investorwords (2015) as a group of individuals who share one or more characteristics from which data can be gathered and analysed. Sampling is a method that allows researchers to choose a representative portion of the entire

population with which to conduct a research study. Sampling techniques can be categorised into two categories: probability sampling and non-probability sampling (Leedy and Ormrod, 2010; Earl, 2007). These two sampling approaches differ with respect to their characteristics and techniques. With regard to their characteristics, probability sampling uses a random selection process, while non-probability sampling uses non-random selection; in a non-probability sampling the researcher uses his/her judgment to select the sample. Concerning their techniques, probability sampling is associated with four techniques: simple random, systematic, stratified and clustered sampling. Non-probability sampling has three sampling techniques, namely convenience, quota and purposive sampling.

Recruiting Test Participants

When the sample of users are recruited, the focus should be on finding users that would be as representative as possible of the intended real users of the system. The sample of users can be recruited directly or through agencies (Barnum, 2002). Direct recruitment involves the evaluator personally recruiting participants. Recruitment through agencies involves third parties such as marketing research companies or employment agencies recruiting test participants on behalf of the evaluator. After the recruitment process, it is important to ensure that all the test participant recruits adhere to the characteristics of the potential study participants. This can be done by requesting all test participant recruits to complete a screening questionnaire.

Preparing the Test Materials

The test materials refer to the different tools that are used in combination with the system during user testing. These include procedure and instruction sheets, consent forms, background questionnaires, pre-test and post-test questionnaires and interviews (Rubin, 1994). Each one of the mentioned test materials will now briefly be discussed.

- Procedure and instruction sheets describe the reasons of the test, the roles of each party involved, and the manner in which users are required to undertake and complete tasks during the test.
- Consent forms serve to make research participants aware of all the benefits, potential risks, confidentiality and costs involved in the test procedure.
- Background questionnaires refer to questions related to the users' demographic information in order to ensure that users represent the target audiences.

- Pre-test questionnaires can assess the users' previous experiences or their knowledge about the system (if any).
- Post-test questionnaires and interviews provide users' overall impressions concerning their interactions with the system.

Ethical Processes

Barnum (2002) advised that it is best to contact test participants in advance (i.e. a day or two before the test day) by means of phone to confirm the appointments. According to Nielsen (1993) and Rubin (1994), there are four crucial components that the evaluator must never overlook when conducting a test: background information and greeting the participants, orientating participants regarding the test, running the test and participant debriefing. As pointed out earlier, most user testing is conducted in a controlled environment. The laboratory setting might be an unfamiliar environment for participants. As a result this might lead to changing of participants' behaviour (i.e. being emotional) or making them feel pressured. Such situations can also affect their performance. Therefore, the evaluator is responsible for creating an environment in which participants are as comfortable as possible. For example, the evaluator should keep reminding participants that it is the system that is being tested and not their abilities.

During the testing session, the evaluator should avoid the following: blaming the participants, being too much in contact with them, or interfering with them while they are performing their tasks. The evaluator must record what users do and say during the testing session (Dumas and Fox, 2008; Dumas and Reddish, 1994). While recording all that, the evaluator should try to stay as far away from the participants as possible. This will allow participants to perform the test by themselves, as well as prevent biasing test results. The evaluator should only intervene if there is a major need.

Preece *et al*. (2011) identified three common ways in which data can be recorded during user testing, namely video recording, audio recording and observing and taking notes. User tests involve collecting various kinds of data on test participants. For that reason, the data collection process should be conducted with deep respect and honesty towards participants. Test participants are human and they also have rights that need to be respected. Their privacy should also be respected. It is best practice to ask participants to sign an informed consent

form. They should always be requested to read the consent form and ask questions about it, if necessary, before signing it.

2.8 Summary

In this chapter the results of a literature review were reported in order to define the research direction for this study. A literature review on the notion of agents, classification of agents, interface agents and related terms were discussed together with examples of the application domains of interface agents. The application of agents in the context of adult computer literacy training in SA was chosen as the focus of this research study. Usability, as well as a number of applicable usability evaluation methods, was discussed. The chapter concluded by suggesting suitable usability methods for assessing the usability of incorporated agents in the context of adult computer literacy training in SA.

The next chapter will provide a detailed discussion on different usability techniques used by the researcher for carrying out usability testing in adult learning environments.

Chapter 3: Research Paradigm and Methodology

3.1 Introduction

As mentioned in Chapter 1, this study aims to establish, through user testing, whether the incorporation of a variety of PIAs can improve and facilitate computer literacy training for adult computer illiterates in SA. The current chapter presents a detailed description of the research paradigm and methodology used in order to achieve the aforesaid study aim. It also discusses reliability, validity and triangulation. Figure 3.1 presents a schematic organisation of Chapter 3.

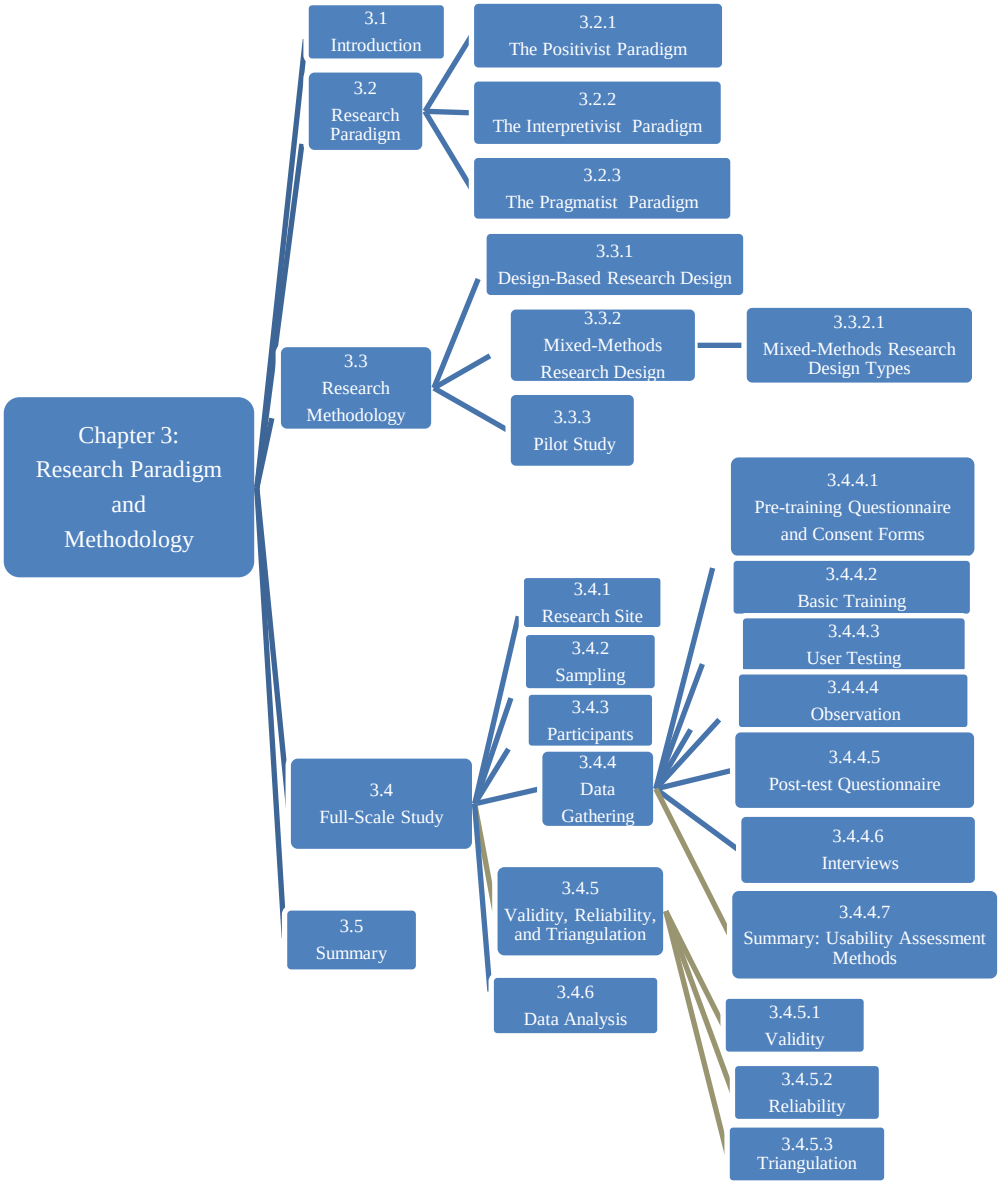


Figure 3.1: Schematic Representation of Chapter 3

Existing literature reveals that there are interchangeable terms that are used to refer to research design. These include *research paradigm* and *research approach* (Johnson and Christensen, 2012). For the purpose of this study, the term *research paradigm* was adopted as it describes theoretical assumptions that underpin the different principles of the research and also provides guidance for conducting the research process (Oates, 2010; Saunders, Lewis and Thronhill, 2009; Yin, 2012).

3.2 Research Paradigm

A research paradigm is also called a *theoretical framework* (Bogdan and Biklen, 2007; Mertens, 2010), *pattern* (Oates, 2010), *worldview* (Creswell, 2009, Creswell and Plano Clark, 2011), or *mental model* (Greene, 2007). In the context of this study, the researcher used the term *research paradigm*. A research paradigm is a basic belief held by a community of researchers concerning the way in which knowledge (data) about a phenomenon should be generated (gathered), analysed and used. This belief system is based on three philosophical perspectives, namely ontology, epistemology and methodology (Creswell and Plano Clark, 2011; Lincoln and Guba, 2005; Oates, 2010; Teddlie and Tashakkori, 2009). Table 3.1 below provides brief explanations of these philosophical perspectives.

Table 3.1: Meaning of Ontology, Epistemology and Methodology

Terms	Meaning
Epistemology	Focus on the actual object of the research, what can be explored, what is the object of one's questions (Cohen *et al.*, 2011; Mertens, 2010).
Methodology	The processes used by the investigator / researcher in order to get the data, information about something of interest that needs to be known (Johnson and Christensen, 2012; Mertens, 2010).
Ontology	How one goes about finding the truth or getting the information in a systematic way (Johnson and Christensen, 2012; Mertens, 2010).

Denzin and Lincoln (2003) and Mertens (2010) pointed out that a research paradigm has an influence on all research stages, starting from deciding on the research problems to analysing and interpreting data. The three philosophical perspectives (see Table 3.1) have underpinned different research paradigms. Existing literature reveals that over the years there has been a proliferation of research paradigms. Some examples of these paradigms include positivist (and postpositivist), interpretivist (constructivism, naturalism, idealism and rationalism), critical theory (transformativism, and realativism), and pragmatist paradigms (Grix, 2004;

Schuh and Barab, 2007; White, 1999). In the context of this study, three types of research paradigms, namely positivist, interpretivist and pragmatist were considered. Grix (2004) affirmed that every research paradigm is based on its own ontological and epistemological assumptions which are reflected in their methodology. The next section will present a brief description of the ontological, epistemological and methodological underpinnings of each of the three research paradigms considered in this study.

3.2.1 The Positivist Paradigm

The positivist paradigm is also called *the scientific method* or *science research* (Oates, 2010). Positivism was introduced in the 19th century by the French mathematician and philosopher Auguste Comte (Cohen *et al.*, 2011). Ontologically, positivists believe that a single concrete reality exists. Their viewpoints on epistemology consist of pursuing objectivity, focusing on facts, seeing the researcher as being independent from study participants, and formulating and testing hypotheses to predict how causes determine effects or describe an experience. Their methodological position uses scientific methods (i.e. experimental designs, testing theories and surveys) that rely on the measurement in order to verify the hypotheses. Quantitative research designs are based on a philosophy of positivism (Hallebone and Priest 2009; Lincoln and Guba, 2005; Saunders *et al.*, 2009).

In the context of this study, measuring the performance of SMOS users alone will not be enough in order to evaluate the usability of PIAs incorporated in SMOS. Hence, for the purpose of this study the use of the positivist paradigm alone will not be sufficient.

3.2.2 The Interpretivist Paradigm

The interpretivist paradigm is also called the *post positivist* paradigm. According to Cohen *et al.* (2011), the origin of interpretivism is linked to three schools of thought, namely phenomenology (direct subjective experiences), ethnomethodology (how people make sense of their everyday life) and symbolic interactionism (subjective meanings or interpretation).

Unlike positivists, the interpretivist researchers ontologically believe that there are many truths and multiple, constructed realities within each situation. The following are their standpoint on epistemology: they are subjective, they focus on understanding what is happening from the subjective experiences of individuals, and the researcher is involved with the study participants. They also use induction to develop ideas about data that they have

collected. Consequently, their preferred methodological choices consist of meaning oriented methods (i.e. interviews, observations, focus groups, document reviews and research diaries). These methods allow for as many variables as possible to be recorded in order to understand information about phenomena being investigated. Qualitative research designs are based on a philosophy of interpretivism (Hallebone and Priest, 2009; Lincoln and Guba, 2005; Saunders *et al*., 2009). In this study, the understanding of SMOS users' subjective experiences about the PIAs incorporated in SMOS alone will not be enough to evaluate the usability of SMOS. Hence, the use of the interpretivist paradigm alone in this study will not be sufficient.

3.2.3 The Pragmatist Paradigm

The origin of pragmatism is linked to the writings of Charles Sanders Peirce, John Dewey and William James in the 19th and early 20th century (Johnson and Christensen, 2012). Ontologically, pragmatists recognised the positivists' and interpretivists' ontological positions, but their focus was on what worked at the time. Hence, the research questions are vital components in pragmatist paradigm. Pragmatist researchers focus most on the *what* and the *how* of the research problem (Creswell, 2009). This allows them to match the research questions with the choice of research methods. The pragmatist epistemology is both subjective and objective, thus they use both induction and deduction. The pragmatists' methodological choices consist of combining both positivist and interpretivist methods (i.e. experimental designs, testing theories, interviews, observations, focus groups, document reviews and research diaries). The choice of using either positivist or interpretivist methods (or both) is directly dependent on the kind of research question (Teddlie and Tashakkori, 2009). The mixed-methods research design and design-based research design are underpinned by the philosophy of pragmatism (Akilli, 2008; Creswell, 2009; Hallebone and Priest, 2009; Johnson and Christensen, 2012; Teddlie and Tashakkori, 2009).

Drawing on the ontology, epistemology and methodology of the three paradigms considered in this study, as well as the aim of this research study (which is to establish through user testing, whether the use of PIAs can facilitate computer training for adult computer illiterates), it appears that pragmatism is the most suitable research paradigm for this study. The following are the reasons for this choice:

- This study seeks to uncover a number of issues related to user testing measurements. Therefore, this needs to be looked at from a number of perspectives (i.e. users'

performance measurement, their individual perceptions of PIAs). For this purpose, as pointed out earlier, using either the positivist or the interpretivist paradigm alone is also not suitable for this study.

- The study addresses a complex problem (i.e. the incorporation of PIAs into adult computer literacy training) of which very little is known. Hence, different kinds of information are required in order to sufficiently explain or offer significant insights into the phenomenon of interest investigated in this study.
- The pragmatism paradigm merges techniques for both the positivist and interpretivist paradigms. Due to the complex nature of this research study, the use of the pragmatist paradigm (i.e. linked to the mixed methods research designs) is advantageous compared to using any single method (i.e. quantitative research designs linked to positivists, or qualitative research designs linked to interpretivists).

As the pragmatist paradigm has been considered as a suitable research paradigm for this research study, it is essential to categorise this study according to the research methodologies that are linked to the pragmatist philosophy.

3.3 Research Methodology

The research methodology is sometimes referred to as the *approach to enquiry* (Creswell, 2007) or *strategy of inquiry* (Creswell, 2009). In the context of this study, the term *research methodology* will be used. Research methodology refers to the distinct types of designs or models that provide guidelines on how research is carried out in the context of a particular paradigm (Creswell, 2009: 11; Sarantakos, 1998: 32).

This research study adopts a pragmatist position. It was mentioned earlier that the mixed-methods research design and design-based research design have been mostly linked to the pragmatist paradigm. In the following sections, some of the key characteristics of the two above-mentioned methodologies will be discussed. Afterwards, a brief comparison of the two methodologies will be presented, and a justification on the choice of methodology employed in this research will be given as well.

3.3.1 Design-Based Research Design

Literature reveals that different terms, such as *design experiments, design research, design study, design science, development research, developmental research* and *formative research*

have been used to refer to design-based research (Alghamdi and Li, 2013; Wang and Hannafin, 2005). An Internet search indicates that the majority of researchers used the term *design-based research*; hence the researcher also opted to use the same term in the context of the current study.

Design-based research focuses on generating useful innovative design interventions to tackle (and solve) complex problems in educational settings (Sari and Lim, 2012; Oh and Reeves, 2010). It aims to develop and improve both theory and practice via closely linked strategies (Abdallah, 2013; Akilli, 2008; Bowler and Large, 2008). For example, in a journal article titled *Design research from a technology perceptive,* Reeves (2006: 59) identified four stages that design-based research goes through and referred to them as:

- Analysis of practical problems by researchers and practitioners in collaboration,
- Development of solutions informed by existing design principles and technological innovations,
- Iterative cycles of testing and refinement of solutions in practice, and
- Reflection to produce design principles and enhance the implementation of solutions.

Instructional Technology PhD students at the University of Georgia (2006) (as cited by Alghamdi and Li, 2013) suggested that design-based research is a better option for researchers who seek to understand variables within a naturalistic real-world context. It is advantageous because design-based research has the ability to offer beneficial methodological tools.

3.3.2 Mixed-Methods Research Design

Mixed-methods research has also been termed *mixed research, mixed method research, mixed methodology, multimethod research, and multiplism* (Jonson and Christensen, 2012). The majority of researchers used the term *mixed-methods research design*, hence this term was also adopted in the context of this study.

In a mixed-methods research, the researcher uses a combination of qualitative and quantitative methods in a single research study to appropriately address the research questions or to obtain rich insights in phenomena under study. The primary goal of the mixed-methods research design is to merge the strengths and improve the weaknesses of both qualitative and quantitative methods (Creswell, 2009; Creswell and Plano Clark, 2011;

Greene, 2007; Hallebone and Priest, 2009). There are five purposes for which mixed-methods can be conducted, namely triangulation, complementary, development, initiation and expansion (Greene, 2007; Creswell, 2009). Table 3.2 below highlights the differences between design-based research and mixed-methods research.

Table 3.2: Design-Based Vs. Mixed-Methods (Adapted from Akilli, 2008)

Criteria	Design-based research	Mixed-methods research
Nature of Relationship	Researchers, designers and practitioners work together in real-world settings	Researchers work together with participants in real-world settings
Objectivity and subjectivity	Blurred objective	Combine objectivity and subjectivity into one study
Purpose/ goal of research	Generate and refine theories in one study	Verify and generate theory in the same study
Tactics	Interventionist in nature	Diverse in nature (eclectic)

As stated in Chapter 1, the main research question for this study is: *What is the level of usability of PIAs used in adult computer literacy training?* The research question plays a crucial role in determining the research methodology because it provides the kind of information needed to answer this question. For example, Hogue (2013) pointed out that before using design-based research, the researcher must examine the research question to ensure that it is a design problem and that it has a real-world impact. Joseph (2004: 236), as cited by Hogue (2013), mentioned that design researchers generally target questions central to the design of the intervention itself. Oh and Reeves (2010) recognised that design researchers rarely conduct summative evaluations as such. Instead, they engage in ever more rigorous forms of formative evaluation. In order to obtain the kind of information needed to answer the main question of this study, the use of mixed-methods research methodologies seems to be more appropriated. The reasons for choosing the mixed-methods research methodology are as follows:

- This research study uses a simulated word processor system called SMOS, developed by Potgieter (2010), which incorporated a variety of PIAs. However, the design problem is not the main target of this study – the study rather seeks to conduct summative evaluations of SMOS.

- The main concern of this study is to assess the extent to which the various PIAs incorporated in SMOS could facilitate the computer training process for adult learners. This is done by means of measuring the usability of these PIAs.
- The usability of PIAs is measured against existing usability attributes (i.e. effectiveness, efficiency and satisfaction). Therefore, this study does not intent to develop theories, or refine any existing ones.
- It is also necessary to understand how adult learners perceive and evaluate SMOS and what meaning SMOS has for them.
- Both objectivity and subjectivity are necessary in order to verify the effectiveness and efficiency of PIAs. This is also true for obtaining information about adult learners' satisfaction with regard to PIAs. Hence, the collection of both quantitative and qualitative data will be very useful to verify whether PIAs incorporated in SMOS fulfill the expectations of adult computer learners. In addition, this data also serve to better answer the research questions from a number of perspectives and also to achieve the research aims and objectives (see Sections 1.3 and 1.4).

The combination of qualitative and quantitative approaches can minimise the weaknesses and make use of the strengths of both approaches. The combination of qualitative and quantitative data also offers the prospect of stronger evidence for conclusions.

3.3.2.1 Mixed-Methods Research Design Types

There are six major types of mixed-methods research designs, namely convergent parallel, explanatory sequential, exploratory sequential, embedded, transformative and multiphase (Creswell, 2009; Creswell and Plano Clark, 2011). This classification is based on the manner (i.e. sequential or concurrent) in which quantitative and qualitative methods are utilised in a particular study and on the importance given to each of them. Table 3.3 gives a brief explanation on each of the six major mixed-methods design types.

Table 3.3: Types of Mixed-Methods Research Designs

Designs	Description
Convergent parallel	In this design both quantitative and qualitative data are given the same level of importance and are collected simultaneously. There is no specific rule with regard to what kind of data (i.e. quantitative or qualitative data) needs to be collected first. Also referred to as simultaneous triangulation (Morse, 1991), concurrent triangulation design (Creswell, 2009), convergent, concurrent or parallel (Creswell, Klassen, Plano Clark and Smith, 2011).
Embedded	One kind of data set is included in another such that the two different types of data sets complement each other in a single study. A particular study can be either largely quantitative or qualitative. Thus, researchers use this design when a largely quantitative or qualitative study needs to include either qualitative or quantitative data in order to answer the research question. Also called a nested design (Creswell *et al*., 2011).
Explanatory Sequential	This design uses a sequential strategy to gather quantitative and qualitative data. The data gathering process is done in two stages. The first stage consists of collecting quantitative data, followed by the second stage, which involves the collection of qualitative data (Creswell, 2009).
Exploratory Sequential	This data gathering process is carried out in two stages. As a result, qualitative data is collected first, followed by the quantitative data collection. The focus is given to qualitative data collection (Creswell, 2009).
Multiphase	This design usually combines elements of sequential and concurrent data collection and analysis approaches within a major research program conducted over a period of time. This design is also called a multiphase project (Creswell *et al*., 2011).
Transformative	This design addresses issues within evolving context (i.e. social justice) by using any design type, such as convergent, explanatory, exploratory or embedded design (Creswell and Plano Clack, 2011;Mertens, 2010).

Referring to Table 3.3 above, the convergent parallel design is the type of mixed-methods design used in this research study. This strategy was selected for several reasons. Firstly, the PIAs incorporated in SMOS have the task of facilitating computer literacy training for adult learners. Hence, this research study should use multiple data collection methods in order to better assess if PIAs are able to achieve their goals. These multiple data collection methods are equally important in the context of this research study. Secondly, in order to address the study aims, the multiple data collection methods used in this study need to be merged. Data merging enables the following: (i) to assess adult learners' performance when using PIAs, (ii) to identify associated factors that affect their performance while using PIAs, and (iii) to understand their individual perspectives of PIAs. Convergent parallel mixed-methods allow convergence of data collected by all methods in a study. Additionally, it attempts to confirm, cross-validate or corroborate findings in a single study. Thirdly, convergent parallel mixed-methods allow data to be collected simultaneously in a shorter period of time compared to other mixed-methods strategies, e.g. sequential strategies. Lastly, the target population of this

study is mostly unemployed, hence they focus more on seeking job opportunities with the result that it often was difficult for them to participate in a research study. It made sense to use this strategy in order to collect as much data as possible during their period of availability and also to save on the cost.

In summary, a convergent parallel mixed-methods design, combining both quantitative and qualitative data collection methods with equal emphasis, was used. This included user testing (performance measurement), pre-training and post-test questionnaires (both open- and close-ended), the researcher's observation notes and interviews.

Each of the data collection methods mentioned was discussed in subsection 2.7.1.1. The following subsections provide a detailed discussion on how each of these data collection methods associated to convergent parallel mixed-methods was used in this study in order to collect data needed to answer the main research question. The discussion starts with the pilot study, which will be followed by the full-scale study.

3.3.3 Pilot Study

Before commencing the full-scale study, the researcher carried out a pilot study. The main reason for doing so was to check the appropriateness of the data collection instruments (i.e. the clearness and answerability of the questionnaires, the SMOS) used in this study. The pilot study was conducted using a group of undergraduate students (n=15) from the Department of Information Technology at the Central University of Technology (CUT), Free State. Each of the participants was given a task sheet consisting of a list of basic word processor tasks (i.e. bold text, underline the text, insert a picture) that needed to be completed using PIAs incorporated in SMOS. After completing their tasks, each participant was further requested to complete a post-test questionnaire. The post-test questionnaire served as a tool for measuring pilot study participants' personal experiences and satisfaction levels concerning the various PIAs that assisted them in performing basic word processor tasks. This further helped to test the unambiguousness and the answerability of questions included in the questionnaire.

The pilot study revealed a number of problems, including that the questionnaire contained too many questions, that participants did not well understand some terms used in the questionnaire, and that participants took too much time to complete the questionnaire. In the

light of these findings, some revisions were made to the questionnaire. Some questions were removed and others were rephrased.

The pilot test proved to be very valuable because it served as a learning process that led to changes being made to the final data collection strategies. It also helped to better understand the technical procedures with regard to the use of PIAs (i.e. it is not possible to use more than one PIA concurrently). Once all changes had been made, the full-scale study commenced.

3.4 Full-Scale Study

In this section a detailed discussion on the various options followed in order to conduct the full-scale study, is presented. These options include the research site, sampling, participants, data gathering and data analysis.

3.4.1 Research Site

This research study was conducted at MUCPP. This is a community centre situated in the Pelindhaba Township at the Mangaung Local Municipality in Bloemfontein, the provincial capital of the Free State Province located in the centre of South Africa. MUCPP was established in 1991 as a partnership between communities, higher education institutions and the services sectors (Department of Labour, 2004). MUCPP was identified as the appropriate setting to conduct the current study because of the following reasons:

- MUCPP's main objective is to promote sustainable livelihoods for previously disadvantaged and unemployed adults in Mangaung, particularly around the townships.
- MUCPP was created to ensure that previously disadvantaged and unemployed adults from the townships have access to learning opportunities (i.e. offers training for adult learners such as computer literacy training and Small, Medium and Micro-sized Enterprises (SMMEs) Business Management training).
- The centre has a mandate to promote skills development for employability of these previously disadvantaged and unemployed adults. Improving their skills would give them an opportunity to participate in social and economic development initiatives within their respective communities, in their province, and even in the country.

The researcher obtained the necessary ethical clearance from his institution (see ethics clearance letter in Appendix A). The researcher requested to meet with the MUCPP manager. From the researcher's point of view, the following were the main objectives for the meeting:

- To explain the purpose of the study to the MUCPP manager,
- To seek the MUCPP manager's approval to conduct the study, and
- To request a venue where the research could be conducted

The MUCPP manager granted the researcher permission to conduct the research study at MUCPP (see permission letter in Appendix B) and in doing so, adhered to all three objectives stated above.

3.4.2 Sampling

Two non-probability sampling techniques, namely convenience sampling and purposive sampling, were selected as appropriate for the purposes of this study. Convenience sampling was used in the pilot study since the researcher was able to easily recruit participants who could volunteer to take part in the pilot study.

Purposive sampling was used to obtain the main study's participants. According to Earl (2007), purposive sampling involves the researcher selecting a sample based on the purpose of the study. The following were the reasons for deeming purposive sampling to be appropriate and advantageous for this study:

- As indicated earlier, SMOS was developed for the purpose of facilitating computer literacy training for adult learners. This implies that adult learners were the target user groups for SMOS.
- The SMOS potential intended users consisted of adult learners with little or no formal educational level, and little or no previous experience with computers. Hence, it was important to get a sample of the targeted SMOS users to test the system.
- The researcher knew where to find candidates who complied with the criteria of the intended users of SMOS (MUCPP).

The study participant recruitment process will now be discussed.

3.4.3 Participants

In this study, the population consisted of adult learners with little or no formal post-school training, little or no previous experience of computers, but with the ability to read and to write English. MUCPP was chosen as an ideal place to recruit potential study participants. As mentioned in Section 3.4.1, the reason for this choice was that MUCPP's objective of promoting skills development for employability of previously disadvantaged and unemployed adults corresponded well with the aims of the research study. In order to facilitate the

recruitment process, the MUCPP manager provided the researcher with a list of names (including contact details) of adult learners who were looking for computer training opportunities. After obtaining their contact details, the researcher scheduled a meeting with the proposed participants. The researcher sent short messages by Short Message Service (SMS) (Appendix C) notifying prospective participants of the venue and the date and time of the proposed meeting. This meeting took place on the MUCPP premises. The objectives of the meeting were the following:

- To clearly explain the purpose of the study;
- To explain the conditions for participation in the study (i.e. no one was forced to participate);
- To explain the training procedures (i.e. participants were to be divided into small groups);
- To explain the protection of a participant's privacy during the study (i.e. data collected from them would only be used for research purposes);
- To explain the importance of their contribution and participation in the study; and
- To explain the rewards for taking part in the study (i.e. no one received any form of cash payment, but they received a computer literacy certificate after successfully completing their training).

3.4.4 Data Gathering

Figure 3.2 shows a visual diagram of the data gathering techniques used in this study. As shown in this Figure, for the purpose of this research study, a pre-training questionnaire, user testing, observation, a post-test questionnaire and interviews were used as the main data gathering techniques. The following subsections will elaborate on how each of the data collection techniques presented in Figure 3.2 was used in the context of this research study.

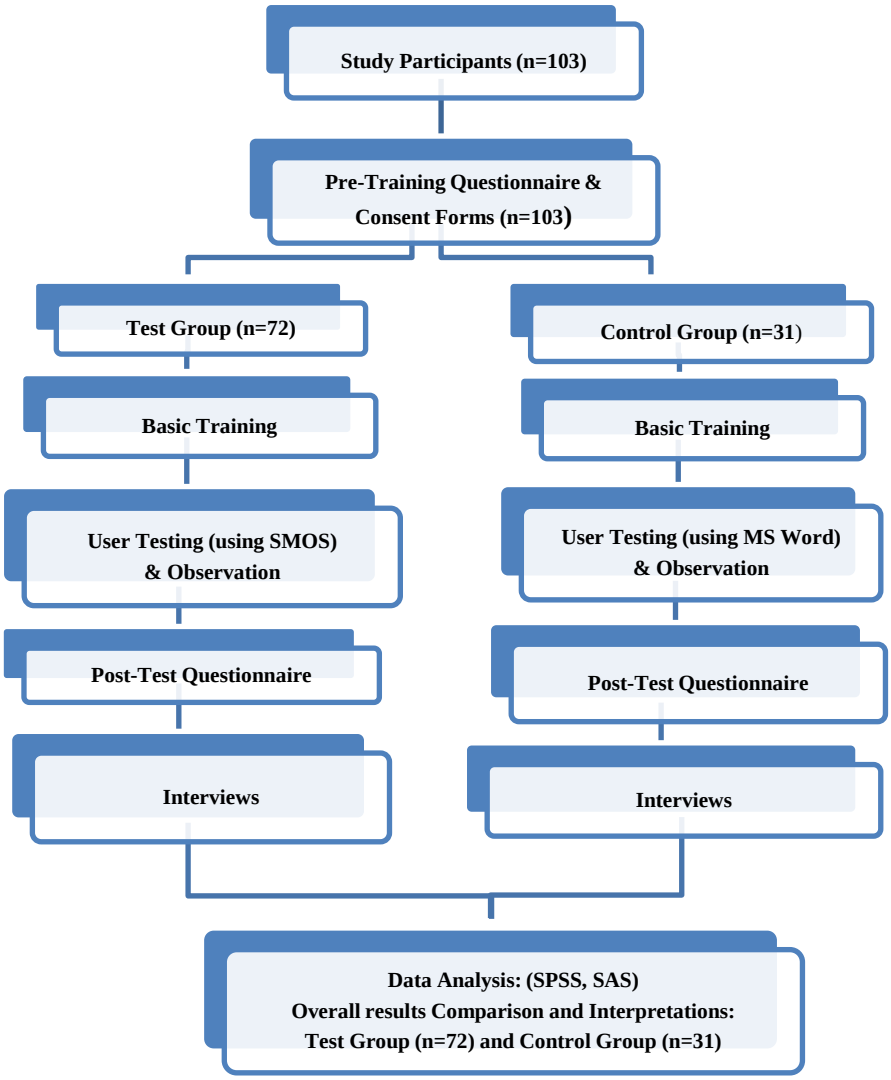


Figure 3.2: Data Gathering Techniques used in this Study

3.4.4.1 Pre-training Questionnaire and Consent Forms

In order to ensure that all recruits complied with the characteristics of potential study participants, they were requested to complete a pre-training questionnaire and a consent form.

The pre-training questionnaire consisted of thirty questions that were divided into four categories, namely Personal Information, Computer Experience, Computer Characters and General Issues. The following were the main reasons for requesting the participants to complete the pre-training questionnaire:

- The researcher needed to get personal information from the candidates (i.e. age, gender, qualifications, etc.).
- The researcher needed to know what the candidates' opinions were about computers and also evaluate their current computer experience, if any.

- The researcher needed to get an idea of the candidates' knowledge, views and attitudes towards educational agents in general.
- The researcher also needed to gather the candidates' views regarding their participation in the study.

The questions contained in the pre-training questionnaire allowed the researcher to do participant screening and to analyse training needs in order to determine the gap between their existing skills, knowledge and abilities and what they needed to be able to use a word processor. Additionally, this assisted the researcher in determining the different topics that had to be covered during the training. The pre-training questionnaire is included in Appendix D.

A consent form was used for ethical reasons. All candidates were requested to read and sign the consent form prior to participating in this research study. The consent form clearly explained what their participation would entail, including their rights and the protection of their privacy. The consent form is included in Appendix E.

The total number of candidates who complied with the participant requirements was 103.

3.4.4.2 Basic Training

Before conducting the user testing, all 103 participants had to undergo basic training. Prior to starting with the basic training sessions, these 103 participants were further divided into two main groups, namely a control group and a test group. This indicated that the basic training was conducted under two conditions, namely with PIAs for the test group consisting of 72 participants, and without PIAs for the control group consisting of 31 participants. In the context of this study, the term *with PIAs* referred to the training condition in which the 72 test group participants were introduced to SMOS and worked with PIAs during their training session. *Without PIAs* referred to the condition in which the 31 control group participants were not exposed to the PIAs, but rather received basic MS Word training. The participants *without PIAs* had no exposure to the PIAs at all.

The main purposes of the basic training were to:

- Introduce all participants to the computer environment and to teach them useful computer skills and basic word processing skills.
- Expose all participants to the computer atmosphere and to familiarise them with the word processing working environment.

- Explain to test group participants what PIAs entailed and what their purpose was.
- Equip test group participants with the necessary skills that would enable them to make use of the PIAs when performing various word processing tasks.

The researcher used data collected from the pre-training questionnaire (Appendix D) to compile the training material used for the basic training. Therefore, the contents of the basic training materials did not include all the word processing tasks, but rather consisted of a selected number of basic tasks that the researcher considered to be relevant for the scope of this study. The outline of the basic training materials is included in Appendix F. It took a total of 13 weeks to carry out the basic training for all 103 participants. The basic training sessions were conducted in the computer laboratory located on the premises of MUCPP. The computer laboratory is shown in Figure 3.3.

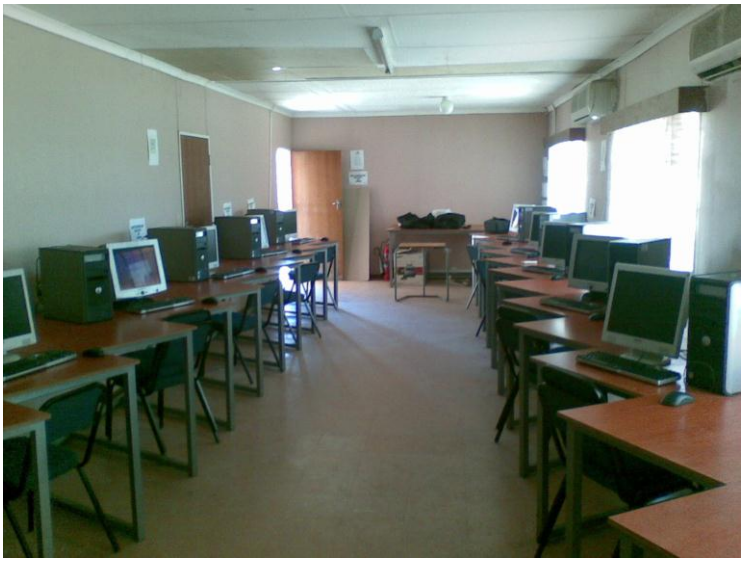


Figure 3.3: MUCPP Computer Laboratory

The computer laboratory contained 10 Personal Computers (PCs) as shown in Figure 3.3 above. Due to the limited number of PCs available, the researcher sent SMSs to participants notifying them of the date and the starting times of their respective training sessions. The SMS can be seen in Appendix G. Each participant was requested to confirm his/her attendance after having received the SMS from the researcher.

During the training each participant was allocated his/her own PC. Hence, the researcher was only able to accommodate one group of 10 participants per training session. Each basic training session took a total of 4 days (Monday to Thursday) and the 5th day (Friday) was reserved for the user testing session.

Days 1 and 2 of the training session consisted of teaching and hands-on exercises performing word processing tasks that were demonstrated by the researcher. Participants were advised to practice what had been demonstrated under the supervision of the researcher. The researcher's demonstrations primarily involved an introduction to the Windows environment, keyboard and mouse skills, and lastly, focused on the word processing environment. Table 3.4 shows a few examples representing Windows basics and basic word processing tasks included in the training material and covered during the training:

Table 3.4: Basic Training Tasks

Tasks	Instructions
Bold	Select the text that you want to bold by highlighting it. To make the text that you had selected bold, click the Home tab on the Ribbon, go to Font group, and click the bold button.
Capitalising a Letter	Hold down the Shift key while you press the key for that letter.
Clicking	Pressing the left mouse button once and releasing it quickly.
Delete Entire Word or Multiple Words	Select the entire word or multiple words to be deleted by highlighting them. Press the delete key on the keyboard.
Double Clicking	Clicking the left mouse button twice in quick succession.
Exit Word	Click the Microsoft Word button. A menu appears. Click Exit Word, which you can find in the bottom-right corner.
Insert New Text	Move the cursor to the specific location (the insertion point) where you would like to insert the new text and click.
Open a Saved File	Click the Microsoft Word button. A menu appears. Click Open. The Open dialog box appears. Use the Look In field to move to the folder in which you saved the file. Click on the file. Click Open.
Start New Paragraph	Press the Enter key twice.

In Table 3.4 *tasks* refer to what is supposed to be done, whereas *instructions* refer to how a particular task should be done. Following the demonstration, hands-on laboratory exercises and training tasks were given to participants on days 3 and 4 as individual work to be done under the supervision of the researcher. These laboratory exercises and tasks were related to the training material presented during days 1 and 2. While doing their various exercises and training tasks participants were allowed to ask questions or request further explanations from the researcher.

As indicated, the researcher used the same basic training materials, hands-on laboratory exercises and training tasks to train both the test and the control groups. The duration of the training sessions was the same for the two above-mentioned groups. However, the different approaches used in training (i.e. with and without PIAs) influenced the way that participants performed their hands-on laboratory exercises and training tasks. The test group participants

did some of their laboratory exercises and training tasks (see Table 3.4) with the assistance of the PIAs, and other tasks without the agents. On the other hand, the control group participants performed all their laboratory exercises and training tasks without the assistance of PIAs since they did not have any knowledge of the PIAs. All 103 participants who received the basic training also participated in the user testing session on day 5.

The next section elaborates on the user testing conducted in this study.

3.4.4.3 User Testing

User testing refers to a performance test (experiment) that was conducted for the purpose of testing the usability of the 10 PIAs incorporated in SMOS. The performance test served to assess how well each of the 10 PIAs incorporated in SMOS could assist adult learners in acquiring basic computer skills. Since SMOS was a finished prototype system, summative usability testing was the convenient kind of evaluation for this study. Efficiency (number of errors), effectiveness (task effort) and satisfaction were the three usability attributes at the centre of the user testing. Hence, three hypotheses namely $\mathbf{H_{0,1}}$, $\mathbf{H_{0,2}}$, and $\mathbf{H_{0,3}}$ were formulated in order to test the usability of the 10 PIAs incorporated in SMOS. Although presented in Chapter 1, they are re-presented here as a reminder.

- **$H_{0,\ 1}$:** There is no difference in the usability performances in terms of effectiveness (number of errors) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.
- **$H_{0,\ 2}$:** There is no difference in the usability performances in terms of efficiency (task effort) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.
- **$H_{0,\ 3}$:** There is no difference in the user satisfaction in terms of amount learnt from the study overall, enjoyment of being part of the study, and willingness to participate in a similar study in future when using PIAs in adult computer literacy training compared to using conventional computer training techniques.

The user testing took place in a controlled environment. As mentioned before, study participants were divided into two groups, namely the test group, consisting of 72 participants (those who used PIAs), and the control group, made up of 31 participants (those who used MS Word). In this study, the researcher performed both within-subject and between-group

comparisons (see subsection 2.7.1.1). Within-subject comparisons examined differences within the test group with regard to their opinions about learning content, effectiveness, and satisfaction related to the respective agents that they used as part of the testing. Between-group comparisons sought to evaluate whether there were differences between participants from the two groups, namely test group (used PIAs) and control group (used MS Word), with regard to the efficiency, effectiveness and study satisfaction levels. The comparison of these two groups was based on the three hypotheses (i.e. $\mathbf{H_{0,1}}$, $\mathbf{H_{0,2}}$, and $\mathbf{H_{0,3}}$) formulated for the purpose of the user testing (i.e. depending on their use of PIAs or not).

Therefore, both a within and a between subject design were utilised in this research project.

The between-group independent variables were the various tasks performed by test and control group participants using their respective systems. On the other hand, the dependent variables were the three usability attributes (effectiveness, efficiency and satisfaction) that were the core of the user testing. As pointed out earlier, two systems (i.e. SMOS and MS Word) were used for the purpose of the user testing conducted in this study. These systems are discussed in the next subsection.

- **Research Tools**

Control group participants used the MS Word system and test group participants used the SMOS during user testing sessions. These two systems differed in terms of their features. The SMOS was developed for the purpose of this study and included limited features and functions necessary to perform this research study. The SMOS features will now be explained.

SMOS

The SMOS is a simulated computer desktop word processor system. A word processor is a computer program that allows users to create, edit and print a document (Teach-ict.com, 2015). MS Word is one example of a commonly used word processor. SMOS was developed to achieve a similar purpose as MS Word, but on a much smaller scale. In order to use the SMOS, the participant had to perform three main steps, namely (i) selecting a particular PIA, (ii) launching the SMOS, and (iii) changing from one kind of PIA to another. The different processes involved in each of these three steps will now be explained briefly.

- Selecting a particular PIA

  The first step consisted of selecting a particular kind of PIA that a participant would have preferred to get assistance from. The following are the various steps that had to be followed in order to select a particular PIA:

  - A double click on the *Choose agent* icon (see Figure 3.4) on the desktop to open the *Choose an agent* window shown in Figure 3.4.

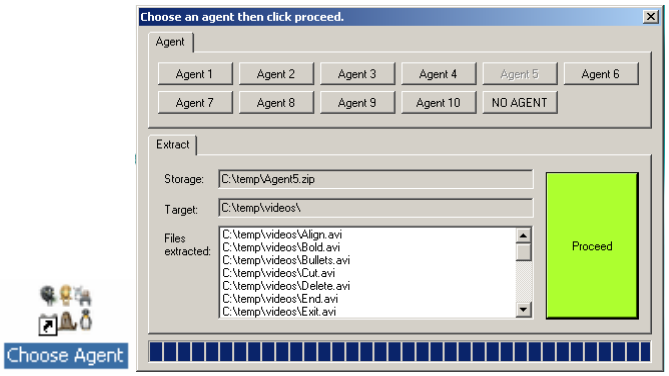


Figure 3.4: Choose Agent Icon and Choose an Agent Window

  - The *Choose an agent* window (see Figure 3.4) contained a list of buttons labelled Agent 1, Agent 2, etc. up to Agent 10. In order to select a particular PIA, the participant had to click on one of those labelled buttons (i.e. in Figure 3.4, Agent 5 Female cartoon human agent 5 was selected). Each of these labelled buttons in Figure 3.4 represented one of the 10 different PIAs that were incorporated in SMOS (see Table 3.5).
  - After a particular PIA selection was made, the participant had to click on the *Proceed* button (see Figure 3.4) to extract the selected PIA.

SMOS incorporated PIAs that had different characteristics. The choice of which PIAs to include in SMOS (Table 3.5) was based on many factors. It was taken into account that the levels of anthropomorphism in a PIA can range from simple to more complex representation and each of these could have different effects on the user. In reality, people may react differently to different types of PIAs. Yan and Agada (2010) pointed out that it is challenging to design PIAs that behave much like a sensitive and effective human tutor. Hence, for the purpose of this study, incorporating a combination of different types of PIAs (i.e. gender, voices and appearances) in SMOS was deemed to be more advantageous than just using one specific kind of PIA.

Table 3.5 below summarises the main characteristics of each of the PIAs. Each of the 10 PIAs was displayed on a blue background.

Table 3.5: PIAs' Images and Characteristics

Agent	Image	Characteristics
Female text (Agent1)		This agent is displayed using a solid animated white text that fades in and out, sentence by sentence.
Male text (Agent 2)		Unlike the female text agent, the male text agent is displayed using a solid animated black text that fades in and out, sentence by sentence.
Female text & audio (Agent 3)		This agent is displayed using a solid animated white text that fades in and out, while a female voice reads the text aloud, sentence by sentence.
Male text & audio (Agent 4)		This agent is displayed using a solid animated black text that fades in and out, while as a male voice reads the text aloud, sentence by sentence.
Female cartoon human (Agent 5)		This is an animated female human cartoon with eyes and mouth that are animated in correspondence with a female voice.
Male cartoon human (Agent 6)		This is an animated male human cartoon with eyes and mouth that are animated in correspondence with a male voice.
Female cartoon dog (Agent 7)		This is a female-looking cartoon dog, white and light brown in colour, with animated eyes and mouth moving in correspondence with a female voice.
Male cartoon dog (Agent 8)		This is a male-looking cartoon dog, brownish in colour, with animated eyes and mouth moving in correspondence with a male voice.
Female realistic dog (Agent 9)		This is a white realistic dog having a female voice with animated eyes and mouth moving in correspondence with an agent's voice.
Male realistic dog (Agent 10)		This is a white realistic dog having a male voice with animated eyes and mouth moving in correspondence with an agent's voice.

After completing the first step, which involved selecting a particular PIA, the next step was launching the SMOS.

- Launching the SMOS

  To start the SMOS, the participant had to double click on the SMOS shortcut icon (see Figure 3.5) on the desktop. By doing so, an SMOS window (see Figure 3.6) opened.

Figure 3.5: SMOS Icon

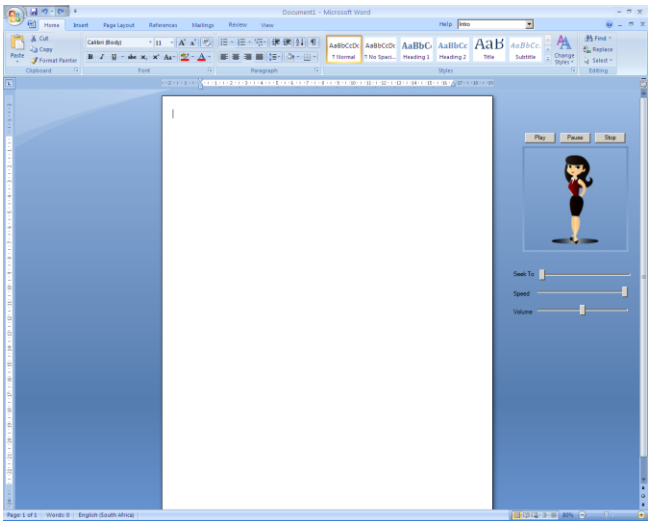


Figure 3.6: SMOS Window

The SMOS window shown in Figure 3.6 above consisted of three main parts, namely the r*ibbon*, the *typing area* and, next to the typing area, there was an area for the *PIA*.

- The ribbon contained a panel of commands that were organised into a set of tabs (mostly as the Tab Bar).
- The typing area was the area where text was supposed to be typed.
- The PIA area contained a particular PIA that the participant chose in step 1. In Figure 3.6 above the female cartoon human (agent 5) was chosen.

Apart from the incorporation of the PIA area (see Figure 3.6) the SOMS system window appeared to be similar to the MS Word 2007 window. The other difference was that since the SMOS was only intended for research purposes, not all the functions of a complete word processor (i.e. MS Word) were included. It rather included some functions that were deemed necessary for the training purpose of this research study. Examples of some of the included functions are presented in Table 3.6.

Table 3.6: Meaning of Functions

Functions	Meaning
Bold	To emphasise text within a document.
Bullet list	List of items by adding a heavy dot before each item in the list.
Change Line Spacing	To alter the number of spaces between lines of a text within a paragraph.
Copy	To copy (duplicate) text within the same document.
Cut	To remove text from the document.
Delete	To remove something (i.e. characters, words) from the document.
Exit Word	Close the application after using it.
Find	Searching for a particular word or phrase in a document.
Font Colour	To choose the colour of characters, text within a document.
Font Size	Font refers to the size of the characters in a document.
Help Function	Assistance on how to work with a particular function, or on how to do a specific task.
Inserting Date	To put the date within the document.
Insert Picture	Place graphics in the document.
Italics	To emphasise text within a document (the letters slanting to the right).
New Document	Create a new, blank document.
Open a Saved File	Opening a saved document for further use.
Paste	To place text that have been copied, at another place within the same document.
Redo	Bring back or restores your original change.
Saving Document	Save a particular document after working with it for later use.
Selecting Text	To choose a character, a word or group of words inside a document by highlighting it.
Text Alignment	The way a paragraph lines up horizontally between different margins.
Underline	To emphasise text within a document by putting a line below a particular text within a document.
Undo	Erase the last change done in the document.
Use Spell Check	To correct spelling and grammar errors in your document as you type.

In this research study, the SMOS was used as training tool to train participants (i.e. adult computer illiterates) in acquiring basic computer word processing skills (see Table 3.6) to create a document (i.e. type a text document), format a document or make changes to a created document (i.e. insert picture, make text bold).

SMOS incorporated 10 different kinds of PIAs (see Table 3.5) that aimed to provide assistance to the users thereof. Hence, each of these 10 PIAs incorporated in SMOS played the role of a tutor. Their assistance mainly consisted of providing the participants with step by step instructions on how to perform a particular task using any one of the various word processor functions (see Table 3.6) included in the SMOS.

The following steps summarise how a participant should go about to get help from a PIA on a particular word processor function:

- In the SMOS, the participant had to click on the *Help* drop-down-list that was located next to the *View* tab on the ribbon.
- The SMOS help drop-down-list appeared (see Figure 3.7) containing a list of word processing functions (e.g. bold, cut, exit, etc.) included in the system.

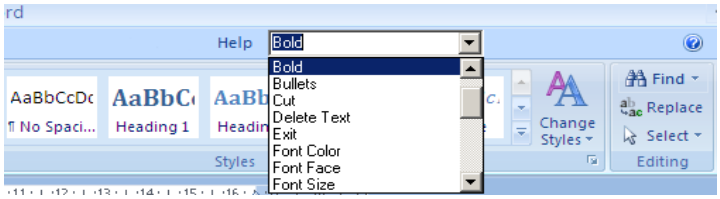


Figure 3.7: SMOS Help Drop-Down-List

- From the help drop-down-list shown in Figure 3.7, a participant could select a particular word processing function that he/she needed assistance with. In this case (i.e. Figure 3.7) the Bold function has been selected
- After choosing the particular function, the PIA (e.g. Agent1, or Agent2) that the participant had selected earlier (i.e. step 1) appeared next to the typing area (see Figure 3.6 in which Female cartoon human (agent 5) was selected) and gave step by step instructions on how to use that particular function to complete the given task.

SMOS also included features that could allow a participant to manipulate the PIA's behaviour. With reference to Figure 3.6, note that there were three buttons situated above the PIA, namely *Play*, *Pause* and *Stop* (as shown in Figure 3.8).

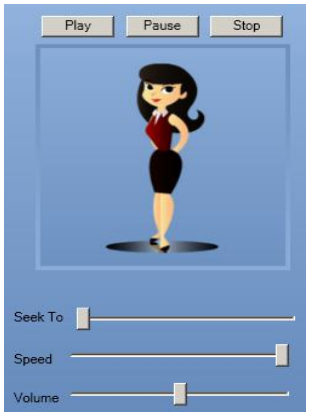


Figure 3.8: PIAs' Control Buttons

- The *Play* button allowed a participant to replay the agent's instructions in case he/she did not understand. This button could also be used to restart the agent after it was paused.
- A participant could use the *Pause* button to stop the agent for a moment or for lengthier periods of time.
- With the help of the *Stop* button, a participant could stop the agent from giving instructions.

In addition to the named three, below the PIA icon (see Figure 3.8) there were also three other buttons (i.e. *Seek to*, *Speed* and *Volume*). These three buttons were slider controls.

- The *Seek to* button enabled the participant to locate (search for) a specific moment in time in the PIA's instructions.
- The *Speed* button served to control the speed (slower or faster) of the PIA's instructions.
- The *Volume* button could be used to control the volume (increase or decrease) of the agent's voice.

It was mentioned earlier that SMOS incorporated 10 different types of PIAs. Hence, the participants could change from one kind of PIA to another.

- Changing from one kind of PIA to another
  After a participant had completed the given tasks with one PIA, he/she needed to do the following in order to select another PIA (i.e. a new PIA):
  - After first ensuring that all changes in the document were saved, a participant had to close or exit SMOS.
  - The participant had to return to the *Choose an agent* window (see Figure 3.4) to select the new PIA and clicked to proceed.
  - A double click on the SMOS shortcut opened the SMOS window again.

Figure 3.9 shows participants A and B using SMOS during the user testing. It illustrates the interaction between participants and PIAs (i.e. participant A was interacting with the female cartoon dog and participant B with the male realistic dog) incorporated in SMOS. Both participants A and B wore headphones in order to better listen to the tips given by PIAs on how to perform their particular word processing task. An example of a dialogue between a participant and an agent is shown in Appendix Q.

Figure 3.9: Participants A and B Interacting with PIAs

Test Tasks

The test tasks included in the user testing were similar, but not identical, to the ones covered in the basic training. The usability metrics were captured by means of test tasks that were given to participants to perform using their respective systems (i.e. SMOS in the case of the 72 test group participants and MS Word for the 32 control group participants). The researcher created one initial word processing document named *MainExercise* (see Appendix H) and also designed two kinds of task sheets: one for the test group participants (Appendix I) and one for the control group participants (Appendix J). These two kinds of task sheets contained the same 11 tasks that had to be completed by participants, as well as detailed instructions on how the 11 tasks were supposed to be completed using the initial document (*MainExercise* in Appendix H) provided to them for the test purpose. Each participant was given a task sheet during the user testing session and participants were instructed to follow the instructions on the task sheet when performing the given tasks using their respective systems. During the user testing session, participants did not receive any help from the researcher. The participants were instructed to use their respective systems if they needed any help. For example, test group participants were told to make use of the PIAs for assistance and control group participants to use normal MS Word *help* features.

Test Measures

The test tasks given to participants during the user testing sought to test the three hypotheses stated in Chapter 1. As per these hypotheses, the measurement of three usability attributes (effectiveness, efficiency and satisfaction) was at the core of the user testing conducted in this study. These three attributes were measured as follows:

- Effectiveness refers to being able to successfully complete a task (Tullis and Albert, 2008: 8). Number of errors was used for measuring the effectiveness of a variety of PIAs incorporated in SMOS.
- Efficiency is the amount of effort required to complete a task (Tullis and Albert, 2008: 8). Metrics that can be used for measuring efficiency include time taken to complete a task, as well as the number of actions or steps taken by a participant to perform a task. The number of steps taken by a participant to perform a task (i.e. task effort) was the efficiency metric that was taken into consideration in this study. A decision was made not to capture task time due to practical issues surrounding the test circumstances. It was mentioned earlier that the targeted participants for this study consisted of adult learners with little or no formal post-school education, or little or no previous exposure to computers, but with the ability to read and to write English. Taking the study participants' profile into account, it was expected that the interactions with computers (i.e. using keyboard for typing, clicking the mouse) might pose a challenge for them. Henceforth, working against time while performing their word processing tasks might unnecessarily have added more pressure on them. For that reason, the time taken to complete a task was not taken into account during the user testing conducted in this study. For the remainder of this research study the term efficiency will be used to refer to the task effort (i.e. the number of steps taken by a participant to perform a task).
- Satisfaction was measured by capturing participants' satisfaction, opinions and judgment and this branded the qualitative measures.

The three usability metrics (i.e. number of errors, task effort and participant's satisfaction) were used to compare how participants in both groups performed during the user testing. It also helped the researcher to benchmark the performance of participants from both groups for determining the level of ease of use of PIAs incorporated in SMOS.

3.4.4.4 Observation

The researcher used observation in order to determine how participants used their respective systems to perform the tasks that they were asked to complete during the user testing. In order to record what was happening during the user testing, the researcher made use of an observation sheet (Appendix K). By means of the observation sheet, the researcher could take notes of observable behaviours exhibited by participants during their interaction with the system that they used during the user testing sessions.

3.4.4.5 Post-test Questionnaire

After completing the user testing session, all participants were requested to complete a post-test questionnaire. The researcher designed two kinds of post-test questionnaires. One was for the test group participants and the other for the control group. Questions included in both post-test questionnaires focused on measuring the participants' personal experiences, including their satisfaction levels regarding the system that they used during the user testing sessions. (As mentioned before, for the test group participants, the term *system* is used to refer to SMOS which incorporated a variety of PIAs, while, with regard to the control group participants, *system* referred to MS Word). The questionnaires included both structured and unstructured type of questions. The question format consisted of a mix of both Likert scaling and open-ended questions. The questions were administered in English. The post-test questionnaire for the test groups consisted of 43 questions and is included in Appendix L. The post-test questionnaire for the control group participants consisted of 31 questions and can be seen in Appendix M.

3.4.4.6 Interviews

The researcher also conducted interviews (see interview sheet in Appendix P) with participants in order to supplement information for some of the post-test questionnaire answers that were unclear. Additionally, it assisted the researcher in clarifying some of the participants' behaviour that were not clearly understood.

3.4.4.7 Summary: Usability Assessment Methods

Figure 3.10 provides a graphical overview of the various usability evaluation techniques available and ones that were used in this study.

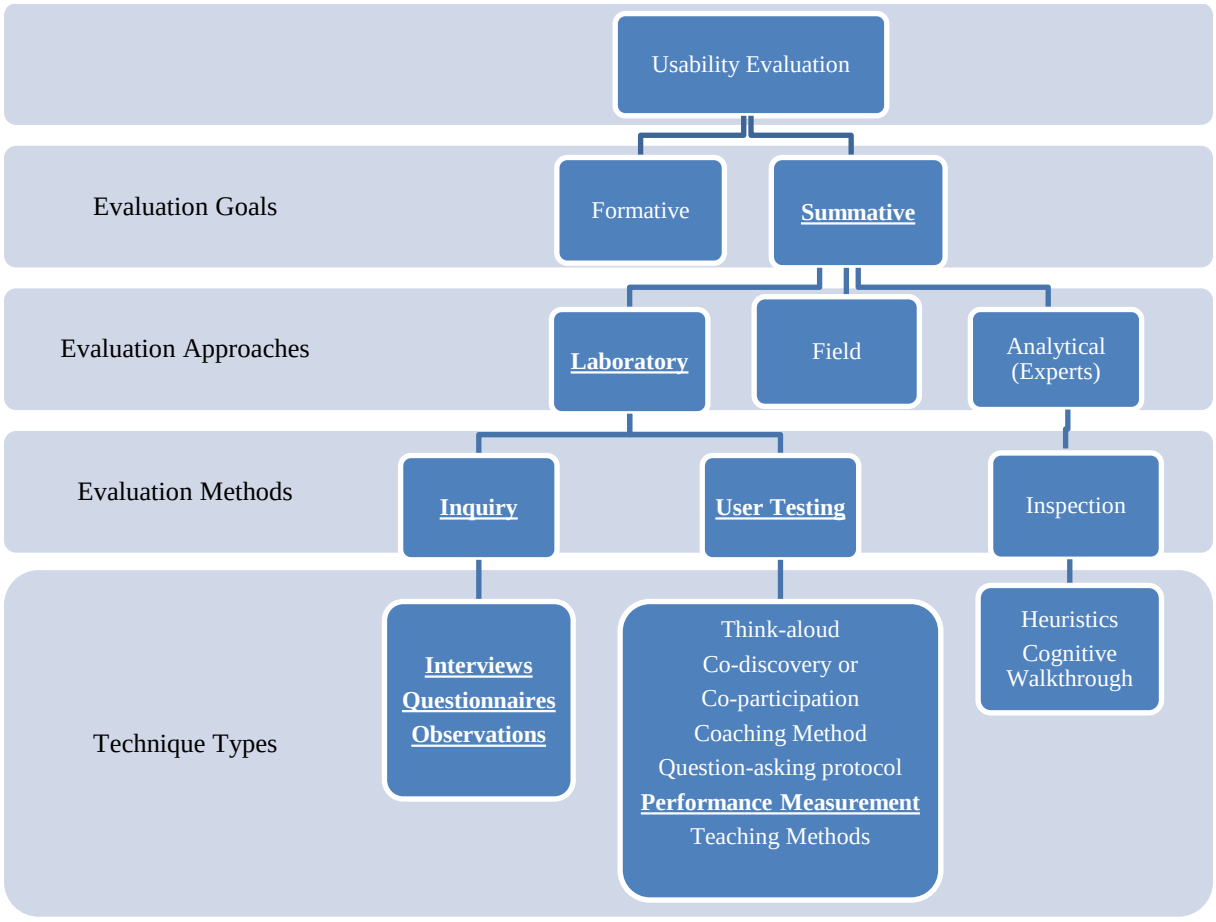


Figure 3.10: Overview of Evaluation Methods used in this Study

With regard to Figure 3.10 above, the items in bold and underlined were the focus in this study. Formative and summative usability evaluations were discussed in Section 2.7.1. Summative evaluation was adopted as a suitable approach to conduct this research study. This was based on the fact that during this study, the researcher used a developed system called SMOS. Hence, the focus of this study was the usability assessment of various kinds of PIAs incorporated in SMOS.

Three usability evaluation methods were introduced and discussed in Section 2.7.1.1, namely inspection methods, inquiry methods and user testing methods. SMOS was developed by Potgieter (2010) for the purpose of facilitating computer literacy training for adult learners. Therefore, it was necessary to use a representative sample of targeted users of SMOS to assess if the system met its main goal. Taking this into account, the researcher selected user testing as a suitable method for assessing the usability of various kinds of PIAs incorporated in SMOS. Seven user testing techniques were discussed in Section 2.7.1.1, namely the think-aloud protocol, co-discovery, coaching method, question asking methods, performance

measurement, teaching methods and remote testing. Among the seven mentioned user testing techniques, performance measuring was selected as a suitable user testing method for the current study. This choice was justified by the fact that performance measuring allows the capturing of data about the performance of a representative sample of the intended users of SMOS while using SMOS to do representative real-world word processing tasks. Three kinds of metrics were collected during the performance measurement user testing, namely number of errors, task effort, and user satisfaction. The main reason for collecting the three named metrics was to assess if SMOS met its main goal (i.e. facilitating the training of adult learners).

Inquiry methods such as questionnaires, observations and interviews were also used as additional data collection methods to clarify or supplement metrics that were collected by means of the performance measurement. The main reason for using both questionnaires and interviews was to get feedback from a representative sample of the intended users of SMOS about their subjective impressions on aspects of the PIAs incorporated in SMOS. Observation allowed the evaluator to look at visible user behaviour while performing tasks. The SMOS summative evaluation was conducted in a laboratory setting. Observation enabled the researcher to discover other behaviours (i.e. visible users behaviour while interacting with the system) that the users could not mention in a questionnaire or interview.

3.4.5 Validity, Reliability, and Triangulation

As already discussed, different data gathering techniques were used in an attempt to answer the research questions investigated in this study. Hence, the issues of validity, reliability, and triangulation needed to be addressed in order to assess the quality of the data gathering techniques used.

3.4.5.1 Validity

Validity is the level of accuracy at which a particular measurement instrument indeed measures what it is supposed to measure (Cohen *et al.*, 2011; Lazar, Feng and Hochheiser, 2008). An important part of this definition is the idea that validity emphasises two main issues, namely the precision of the measurement instruments and their ability to carry out their measurement tasks. Types of validity include internal, external, catalytic, consequential, content, construct, convergent and discriminant, criterion-related, cross-cultural, cultural, and ecological validity (Cohen *et al.*, 2011). However, two types of validity, namely internal and

external validity, were considered in the context of the current study. Internal validity ensures that the researcher observes and measures what he/she intends to measure. External validity is concerned with the generalisation of the research results beyond the subjects under investigation to a wider population. Johnson and Christensen (2012) argued that, since several types of validity evidence can be collected, it is best to collect multiple sources of evidence. Denscombe (2008) added that the use of mixed-methods is beneficial over mono-method use because it avoids biases and increases data validity.

In the context of this research, a mixed-methods approach was used to investigate the problem from different angles and to strengthen the validity of the findings. Triangulation, achieved in this research study by applying the multi-method research approach, will be discussed in subsection 3.4.6.3. The researcher also decided to use a representative sample of the target population (i.e. adult computer illiterate users). All performance tests and questions included in the questionnaires and interviews were linked to the research aims and objectives, and attempted to cover as much as possible of the aspects of the phenomenon under investigation. Collected data was analysed with a degree of accuracy using content analysis principles. These principles were useful because they assisted the researcher in the search for patterns of understanding and problems that emerged from the data (Krippendorff, 2012).

3.4.5.2 Reliability

Reliability refers to the ability of a research finding to prove that, if it was to be carried out with a similar group of respondents in a similar context, similar results would be obtained (Cohen *et al.*, 2011: 199). From this definition, it can be deduced that reliability basically means the consistency of a measure. Lazar, Feng and Hochheiser (2008: 298) pointed out that reliability checks span two dimensions, namely stability and reproducibility. Stability is concerned with consistency over time and similar samples. Reproducibility has to do with the extent of consistency across different tests (among the items to be measured). Oates (2010) stressed that reliability is usually difficult to assess because respondents could change their views over time, remember the answers they gave last time, or even deliberately decide to give the opposite view this time. Seale (2011) identified reflexive methodological accounting as a way to increase faith in the truth-value of the research findings. Hence, Oates (2010) and Seale (2011) advised that the researcher should provide sufficiently detailed accounts of methods that have led to a particular set of conclusions.

It is true that within the researcher community, there could be other researchers interested in this study and who might want to replicate it. It is understandable that the conditions might differ when replicating the current research. Hence, in an effort to enable others to gain a good understanding of various decisions and procedures adopted in this research and to increase the probability of replicating this research, all aims, objectives, justifications of the adopted research paradigm and methods, decisions and procedures were specified clearly.

3.4.5.3 Triangulation

Triangulation can be defined as combining more than one method of data collection when investigating a particular fact (Bogdan and Biklen, 2007; Cohen *et al.,* 2011). Lazar, Feng and Hochheiser (2008) indicated that the use of multiple research methods can strengthen the weight of evidence. Oates (2010) added that triangulation provides researchers with multiple modes of attack in terms of their research question. Johnson and Christensen (2012: 439) asserted that triangulation can substantially increase the credibility or trustworthiness of a research finding. Several kinds of triangulation can be employed in the same investigation, including theoretical, investigative, methodological, and data triangulation (Denzin, 2006).

Two of these types of triangulation, namely data and methodological triangulation, were considered in the context of the current study. Data triangulation refers to the use of more than one data source in a study in terms of person, time and space. Methodological triangulation involves the use of multiple methods to collect data.

Both data and methodological triangulation were achieved by using mixed-methods to collect data from different sources. These included user testing (i.e. performance tests), questionnaires (i.e. pre-training and post-test) containing a mix of open-ended and closed-ended questions, direct observation, and interviews. These multiple methods assisted the researcher in consolidating the strengths and offsetting most of the weaknesses of each of the data collection methods.

The next section will introduce and briefly explain the data analysis strategies used in this study.

3.4.6 Data Analysis

Various types of quantitative data (i.e. participants' performance measurements) were obtained from the user testing. Qualitative data (i.e. participants' experiences, evaluation or

preferences) were obtained by means of questionnaires, observation and interviews. These two kinds of data were analysed using SPSS and SAS software packages. The results of the comparative statistical test analyses were interpreted, discussed, and displayed in tables.

Quantitative analysis (i.e. to test hypotheses $\mathbf{H_{0,1}}$, and $\mathbf{H_{0,2}}$) was used to:

- Compare data on control and test group participants' effectiveness (number of errors), and efficiency (task effort) in performing different tasks using their respective word processing systems (i.e. SMOS for test group, and MS Word for control group).
- Collect data on the relationship between diverse variables used in the study.
- Present data in the form of statistics and aggregated data.

At the same time, qualitative analysis was used in this study for the purpose of:

- Obtaining participants' subjective impressions about their interaction with the respective word processing systems during user testing (i.e. impressions on a variety of PIAs incorporated in SMOS for test group participants, and impressions on MS Word for the control group participants).
- Comparing control group and test group participants' satisfaction (i.e. to test hypothesis $\mathbf{H_{0,3}}$) in terms of the amount learnt from the overall study, the enjoyment of being part of the study, and the willingness to participate in a similar study in future.

The integration of the two above-mentioned data types allowed for a more comprehensive understanding required to inform decision making, as well as to produce more data, which could improve the quality of this study. The results from the comparative statistical test analyses of the various user tests performed, observation, as well as the interviews conducted by the researcher, were used to draw conclusions. These conclusions helped the researcher to measure the usability of PIAs in terms of the following:

- How effective is it for participants to perform their computer training tasks with the assistance of PIAs?
- How efficient can participants complete their computer training tasks with minimum effort using the assistance provided by PIAs?
- How do participants feel about their ability to accomplish their computer training goals using PIAs?

The above-listed then allowed the researcher to:

- Identify the changes in knowledge, attitude and aspiration of computer literacy training program participants based on their computer literacy training with PIAs.
- Propose ways in which to incorporate PIAs in order to improve adult computer literacy training.
- Present guidelines on how to improve adult computer literacy training in SA.

In Chapter 4 a more detailed clarification of the data analysis, data interpretation, including the data discussion, will be provided.

3.5 Summary

In Figure 3.11, the items in bold and underlined represent the various options chosen in the process of determining the suitable methodology for this study.

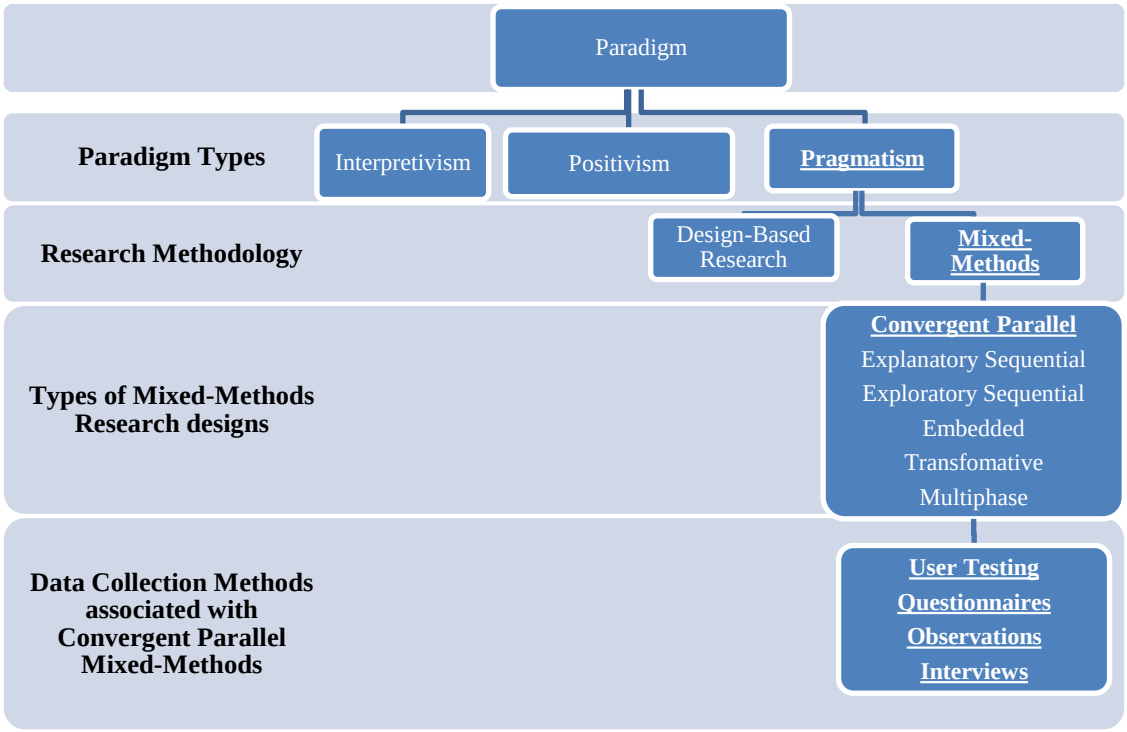


Figure 3.11: Overview of the Methodology used in this Study

The Pragmatist paradigm was chosen as a suitable research paradigm for this study. From the two research methodologies linked to the pragmatist paradigm, the mixed-methods research design (specifically convergent parallel design) was chosen. Before commencing the full-scale study, a pilot study was conducted to assess the appropriateness of the data gathering techniques and instruments that were to be used to answer the research questions. The

different procedures used in the full-scale study, such as research site, sampling, participants and data gathering usability testing plan, were discussed in detail. A summary was given of the kinds of usability assessment methods considered to be suitable for this study. The data analysis techniques for the data obtained during the full-scale study were explained. Lastly, reliability and validity, as well as triangulation, were discussed.

Chapter 4: Data Analysis and Interpretation

4.1 Introduction

Chapter 3 discussed the research paradigm used to carry out the current study, and outlined the data collection strategies. Figure 4.1 below is a schematic representation of the organisation of Chapter 4.

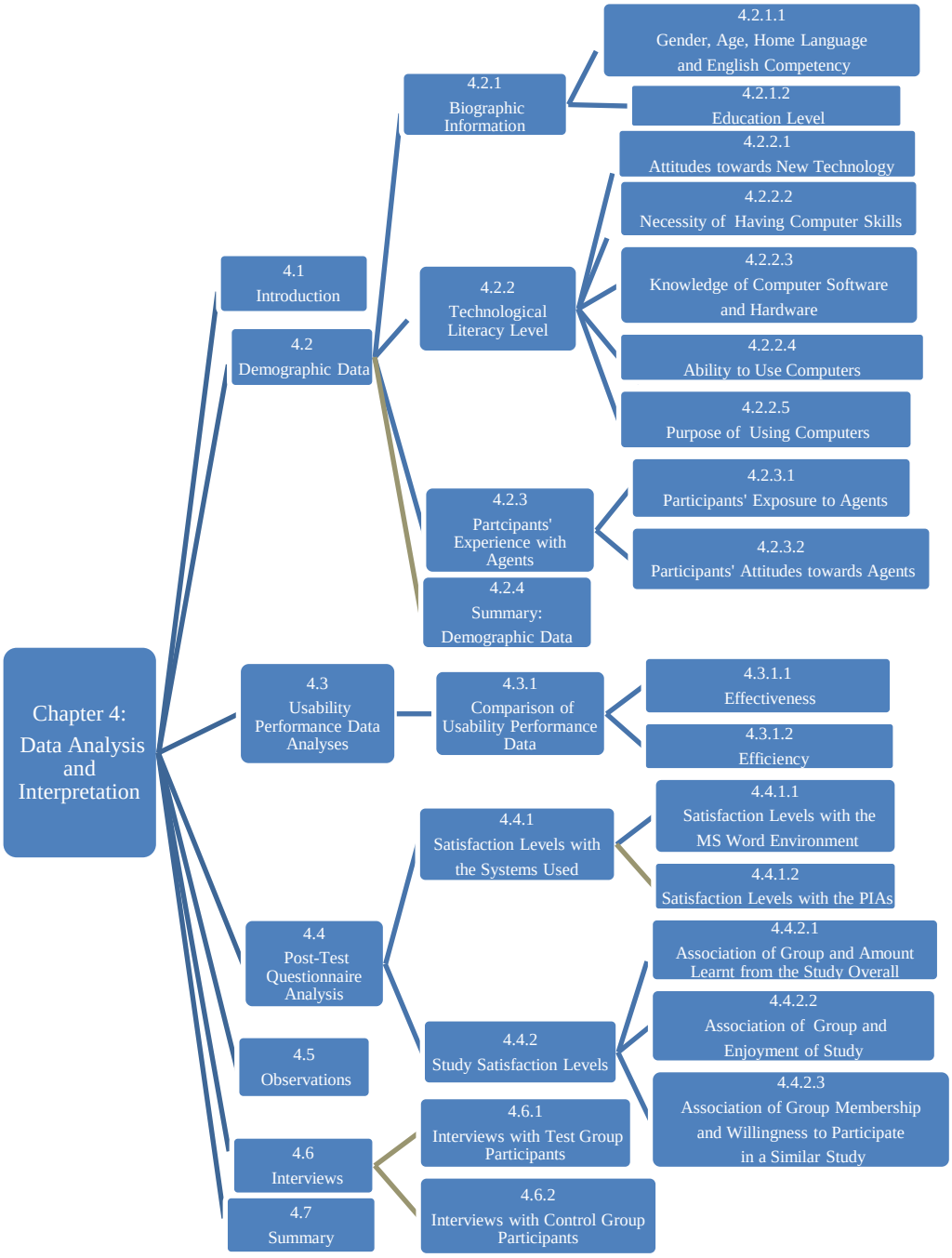


Figure 4.1: Schematic Representation of Chapter 4

4.2 Demographic Data

As mentioned earlier, the characteristics of the target adult learner population in this study were as follows: (i) little or no formal post-school education, (ii) literate in terms of being able to write and read English (as well as understanding and speaking English), and (iii) little or no previous exposure to computers. As described in subsection 3.4.4.1, the pre-training questionnaire (see Appendix D) was administered before the basic computer literacy training sessions commenced, and was completed by all the participants (103). The demographic questions included in the pre-training questionnaire served to collect general information about the study participants. This information was then used to describe the study participants and to assess whether they adhered to the profile of the target population.

The demographic data analysis is presented in three parts. The first part presents the information collected through the biographic information question. The second part presents the information collected through the question related to the participants' technological literacy level, and the third part presents the information collected through the question related to participants' experiences with regard to agents. Note that the results presented here relate only to the participants who were part of the main study. Study participants who did not respond to some of the questions were excluded from the data analysis presented here. This was done to avoid those answers affecting the results. Likewise, the pilot study data was not taken into consideration.

4.2.1 Biographic Information

The purpose of the biographic questions was to give an indication of the profile of the study participants. Biographic questions included participants' gender, age, home language, English competency and education level.

4.2.1.1 Gender, Age, Home Language and English Competency

The data related to participants' gender, age, home language and English competency level (questions 3 to 6 in Appendix D) are summarised in Table 4.1. There was a total of 103 participants of which 62.0% were females and 38.0% males. The participants' age ranged from less than 20 years to over 40 years; the majority of participants (56.0%) were between 20-30 years of age, while a small number of participants (4.0%) were older than 40 years.

Table 4.1: Gender, Age, Home Language and English Competency

Variable	Category	Frequency	%
Gender	Male	39	38.0
	Female	64	62.0
	Total	**103**	**100.0**
Age group	< 20	14	14.0
	20-30	55	56.0
	31-40	26	26.0
	> 40	4	4.0
	Total	**99**	**100.0**
Home language	Sesotho	49	49.0
	Setswana	28	28.0
	Xhosa	17	17.0
	Zulu	1	1.0
	Not specified	5	5.0
	Total	**100**	**100.0**
Understand English	Good	95	98.0
	Average	2	2.0
	Total	**97**	**100.0**
Speak English	Good	97	98.0
	Average	2	2.0
	Total	**99**	**100.0**

The majority of the participants (49.0%) indicated Sesotho as their home language, while others indicated Setswana (28.0%), Xhosa (17.0%) and Zulu (1.0%). Only 5.0% of participants did not specify their home language. The majority of participants (98.0%) indicated that they understand the English language well. The remaining 2.0% had an average understanding of English. With regard to speaking English, the majority of participants (98%) indicated that they were fluent in English. The remaining 2.0% were average speakers of the English language.

In summary: Study participants consisted of both genders (i.e. male and female) where the number of female participants was dominant. Study participants' ages varied and most of them fell in the age group 20-30 years of age. Setswana speaking participants formed the majority. Although English was not participants' home language, they all had the ability to both understand and speak English.

4.2.1.2 Education Level

The education level of the participants (question 7 in Appendix D) is presented in Table 4.2. Most participants (68.0%) had a matric certificate as highest qualification, while 22.0% passed Standard 9 (Grade 11), and 6.0% passed Standard 8 (Grade 10). Only 2.0% passed

Grade 9, 1% obtained an N3 engineering qualification and another 1% did not specify their qualification level.

Table 4.2: Qualification of Participants

Variable	Category	Frequency	%
Qualification	N3 Engineering	1	1.0
	Matric Certificate	70	68.0
	Standard 9 (Grade 11)	23	22.0
	Standard 8 (Grade 10)	6	6.0
	Grade 9	2	2.0
	Not specified	1	1.0
	Total	**103**	**100.0**

From the data summarised in the Table above, it can be noted that participants held different education levels, but most of them had a matric certificate as highest qualification.

4.2.2 Technological Literacy Level

Technological literacy questions assessed the approximate level of participants' understanding of what technology is, how it works, their level of exposure to technology, and reasons for using it (or not). Data collected about participants' technological literacy level included the following: (i) attitude towards new technology, (ii) views on the necessity of having computer skills, (iii) knowledge of computer software and hardware, (iv) ability to use computers, and (v) the purpose for using computers. The data for each of the five aspects mentioned above are now presented.

4.2.2.1 Attitudes towards New Technology

The purpose of the attitude questions (Appendix D, questions 9 and 10) was to elicit general opinions from participants on their feelings and thoughts regarding new technology. These results are displayed in Table 4.3 below.

Table 4.3: Attitudes towards New Technology

Question	Category	Frequency	%
Are you scared to learn how to use new technology?	Yes	11	11.0
	No	91	89.0
	Total	**102**	**100.0**
Do you feel threatened when others talk about computers?	Yes	11	11.0
	No	90	89.0
	Total	**101**	**100.0**

The majority of participants (89.0%) indicated that they were not scared to learn how to use new technology. Similarly, 89.0% of participants indicated that they did not feel threatened when others talked about computers.

Therefore, the data on participants' attitudes towards new technology indicated that participants generally were positive about embracing new technology.

4.2.2.2 Necessity of Having Computer Skills

The questions related to the necessity of having computer skills (questions 12 to 14 in Appendix D) aimed to investigate the participants' awareness about the impact and influence of technology literacy in their lives, as illustrated in Table 4.4 below.

Table 4.4: Computer Skills Necessity

Question	Category	Frequency	%
Do you think it is important for you to learn how to use a computer?	Yes	97	95.0
	No	5	5.0
	Total	**102**	**100.0**
Do you think learning about computers will give you opportunities to learn about many new things?	Yes	102	99.0
	No	1	1.0
	Total	**103**	**100.0**
Do you think knowing how to work with computers will increase your job possibilities?	Yes	100	99.0
	No	1	1.0
	Total	**101**	**100.0**

Most participants (95%) acknowledged that it was important to learn how to use a computer. Similarly, virtually all participants (99.0%) recognised that learning about computers would give them a variety of opportunities and would increase their job opportunities.

The data above revealed that study participants were very much aware of the usefulness of having computer skills. They also agreed that computer skills would have an impact in their career opportunities as well as increase their employability.

4.2.2.3 Knowledge about Computer Software and Hardware

This category of questions (Appendix D, questions 20, 22, 23 and 24) aimed to assess the level of participants' theoretical and practical understanding of how computer software and hardware worked. Table 4.5 summarises these results.

Table 4.5: Hardware and Software Knowledge

Question	Category	Frequency	%
Do you understand how a computer works?	Yes	30	30.0
	Uncertain	39	38.0
	No	33	32.0
	Total	**102**	**100.0**
Do you know something about an operating system (e.g. Windows)?	Yes	38	38.0
	No	63	62.0
	Total	**101**	**100.0**
Do you know the layout of a keyboard?	Familiar	25	25.0
	Fairly familiar	40	40.0
	Not familiar	35	35.0
	Total	**100**	**100.0**
Do you know how to handle the mouse?	Yes	76	75.0
	No	26	25.0
	Total	**102**	**100.0**

The majority of participants (38.0%) were uncertain on how a computer works, and a further 32% did not know at all. Only 30% of participants affirmed that they had knowledge of a computer's functionality.

Most of the participants (62.0%) confirmed that they did not know anything about an operating system. Furthermore, the results in Table 4.5 indicate that 25.0% of all study participants were familiar with the keyboard layout, 40.0% were fairly familiar, while 35.0% were not at all familiar with the layout of a keyboard. Concerning mouse handling, most participants (75.0%) confirmed that they were able to handle the mouse; the remaining 25.0% did not know how to handle the mouse.

The data presented in Table 4.5 indicated that many participants lacked theoretical understanding of a computer's functionality and operating systems. Nevertheless, they demonstrated a level of theoretical understanding about the layout of a keyboard and had practical experience with a mouse.

4.2.2.4 Ability to Use Computers

The ability question (question 15 in Appendix D) sought to investigate if the participants had the necessary experience to successfully perform a task with a computer. Table 4.6 presents the analysis.

Table 4.6: Ability to Use Computers

Question	Category	Frequency	%
Did you ever work with or use a computer before?	Yes	54	52.0
	No	49	48.0
	Total	**103**	**100.0**

A total of 54 participants (52.0%) had used a computer before and the rest (48%) had not.

The above data shows that only about half of the study participants had previously been exposed to computers.

4.2.2.5 Purpose of Using Computers

Questions in this section (questions 16 and 17 in Appendix D) were directed specifically to participants who indicated that they had used a computer before (see Table 4.6). The purpose of these questions was to investigate various reasons that motivated this group of participants to use computers and also to determine the period of time they spent on the computer. The data are summarised in Tables 4.7 and 4.8 respectively.

Table 4.7: Purpose of Using Computers

Purpose of computer usage	Total	%
Typing a document	31	57.0
Playing games	19	35.0
Sending email	8	15.0
Playing music	20	37.0
Browsing the Internet	12	22.0

Among the 54 participants who had used computers before (see Table 4.6), 57.0% indicated that they used a computer for typing a document, 37.0% for playing music, 35.0% for playing games, 22.0% for browsing the Internet, and 15.0% for sending email.

Table 4.8: Frequency of Using Computers

Rate of computer usage	Total	%
Daily	13	27.0
Weekly	14	29.0
Monthly	18	38.0
Occasionally	1	2.0
Scarce	1	2.0
Not specified	1	2.0

According to Table 4.8, 38.0% of the 54 participants with computer experience used a computer monthly, 29.0% weekly, 27.0% daily, 2.0% occasionally, and 2.0% scarcely. The other 2.0% did not specify frequency of use.

Table 4.7 showed that the majority of participants used a computer for typing a document, playing music and playing games. Based on the information in Table 4.8, it can be noted that computers are mainly used monthly, followed by weekly and daily.

On the other hand, there was a total of 49 study participants (48.0%) who indicated that they had never used a computer before (see Table 4.6). This group of participants were asked (question 18 in Appendix D) to indicate if they knew how to switch on a computer. Their responses to this question are summarised in Table 4.9 below.

Table 4.9: Switching on a Computer

Question	Category	Frequency	%
Do you know how to switch or turn on a computer?	Yes	26	58.0
	No	19	42.0
	Total	**45**	**100.0**

According to the data in Table 4.9, the majority (58.0%) of participants in this group indicated that they knew how to switch on a computer; the remainder (42.0%) did not know how to do that. Therefore, more than half of the participants in the group who had never used a computer before knew at least how to switch on a computer.

In summary, participants' technological literacy level data suggested that there were differences among participants in terms of their levels of theoretical understanding and practical exposure to technology. However, regarding their attitudes towards new technology and their awareness of the impact of technology in their lives, there was no difference among participants.

4.2.3 Participants' Experience with Agents

The purpose of the questions regarding previous experience with agents was to provide an understanding of whether participants have worked with interface agents before, and their attitudes towards them.

4.2.3.1 Participants' Exposure to Agents

The data concerning participants' exposure to agents (question 28 in Appendix D) is presented in Table 4.10.

Table 4.10: Exposure to Agents

Question	Category	Frequency	%
Have you ever played a game using your cell phone?	Yes	93	91.0
	No	9	9.0
	Total	**102**	**100.0**

As Table 4.10 shows, nearly all participants (91.0%) had played a game using their cell phones.

4.2.3.2 Participants' Attitudes towards Agents

Participants were asked questions (Appendix D, questions 29 and 30) about their attitudes towards agents. Their reactions are presented in Table 4.11 below.

Table 4.11: Attitudes towards Agents

Question	Category	Frequency	%
What is your attitude towards different human being's roles being played by different characters (e.g. dog, cat, robot, etc.) that are used in games or animated films?	Positive	55	56.0
	Fair	35	35.0
	Negative	9	9.0
	Total	**99**	**100.0**
Do you believe that those characters (e.g. dog, cat, robot, etc.) are able to perform whatever task or action they are supposed to perform in games or animated films?	Yes	85	83.0
	No	17	17.0
	Total	**102**	**100.0**

As per Table 4.11, the majority (56.0%) of participants indicated that they were positive towards human being's roles *being* played by different characters (i.e. dog, cat, and robot) in games or animated films, while 35.0% had fair and 9.0% had negative attitudes towards such role playing. A good number of participants (83.0%) agreed when asked if they believed that those characters (i.e. dog, cat, and robot) were able to perform human being's roles or actions in games or movies.

In summary, participants revealed there were differences between them in terms of their level of interactivity with agents. On the other hand, it was also noted that there was no clear difference regarding their attitudes towards agents.

4.2.4 Summary: Demographic Data

The demographic data revealed that study participants had the ability to speak and write English. The sample consisted of both genders, indicating that both males and females were

interested in this study. However, the number of female participants was higher than their male counterparts. This might be because females, especially in a 3rd world setup, are seeking self-development opportunities to provide them with equal opportunities when compared to their male counterparts. Females might be attempting to overcome gender stereotyping by tradition and society, and might endeavour to increase their representation in a predominantly male domain (i.e. computer technology field). With regard to participants' ages, it was noted that most of the study participants were between the ages of 20 and 30 and that the vast majority had a matric certificate as highest qualification. There are a few possible explanations for this result pattern. Firstly, according to the 2015 first quarter results of the Quarterly Labour Force Survey (QLFS) published by Statistics SA, as many as 3,6 million young people (aged 15-34) were unemployed and actively looking for work (Statistics SA, 2015). A second possible explanation might be that people in this group age are school leavers; often their focus is on trying to find a smooth transition from school to work. As a result, they look to participate in similar programs as provided by this research study where they might acquire apprenticeship training to acquire the necessary skills that will enable them to enter the labour market and increase their chances of employment.

Additionally, the demographic data revealed that a few of the study participants previously had some kind of interactive experience with agents. This could be explained by the fact that cell phone ownership was common among study participants. Statistics show that about 89% of South Africans have cell phones (Nowak, 2015). Hence, the proliferation of cell phones among participants exposed them to agents, probably while playing games.

4.3 Usability Performance Data Analyses

The assessment of the usability of PIAs, in terms of effectiveness, efficiency and satisfaction, on adult computer literacy training was the core of the user testing conducted in this study. Participants were divided into two groups, namely test (with PIAs) and control (without PIAs) groups. During user testing, both groups were given 11 tasks to complete as part of the assessment. The test group participants used SMOS to complete their tasks (Appendix I), while the control group participants used MS Word 2007 (Appendix J). The usability metrics were captured while the two groups of participants were working on the tasks assigned to them using the respective software tools. The primary objective of the statistical analysis was to compare the usability performance and satisfaction data of test and control group

participants in order to assess the degree to which SMOS with its incorporated PIAs met the three usability criteria (effectiveness, efficiency and satisfaction).

All comparative statistical test analyses were carried out using SPSS and SAS software packages.

4.3.1 Comparison of Usability Performance Data

Performance data refers to data related to the 11 assessment tasks that test and control group participants completed during the user testing session. In this section, the comparison of performance data between test group (68) and control group (31) participants is reported. The performance data were effectiveness (number of errors) and efficiency (task effort). It should be noted that 4 participants in the test group failed to submit the correct documents so that these 4 participants were not included in the statistical analysis. Therefore, with regard to the usability performance data, 68 test group participants were included in the analysis.

4.3.1.1 Effectiveness

In this section, the statistical analysis of the effectiveness data (number of errors) is discussed.

The following hypothesis was formulated about the effectiveness of PIAs:

$H_{0,1}$: *There is no difference in usability performance in terms of effectiveness (number of errors) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.*

A significance level of alpha equal to 0.05 was used to test the null-hypothesis above, as well as all other null-hypotheses formulated in this research study. Test statistics associated with a P-value less than alpha are referred to as statistically significant. Furthermore, whenever possible, between-group comparisons are presented as estimates and 95% confidence intervals of appropriate between-group contrasts, such as between-group differences of means, or between group ratios of rates.

Number of Errors

During user testing, the 11 tasks were given a score as follows: The maximum score for the tasks varied from 1 to 4, depending on the complexity of the task (refer to task score sheet in Appendix N). For each error, incomplete step or missed step while executing the task in question a value of one was subtracted from the maximum score for the task. Thus, the score awarded for the individual task was equal to the maximum score for the task minus the number of errors committed while executing the task. With regard to statistical analysis of the number of errors, both the number of errors for each individual task, and the total number of errors for all 11 tasks, were considered. The following subsections will first present the results for each individual task, where after the results regarding the total number of errors will be presented.

Number of Errors for Each Individual Task

As mentioned above, the maximum score for the individual tasks varied from 1 to 4, depending on the complexity of the task. Thus, the number of errors for each individual task was an ordinal categorical variable with, depending on the task, up to five categories (0, 1, 2, 3 or 4 errors). The number of errors for each individual task was therefore compared between groups (*with agents* versus *without agents*) using the Mantel-Haenszel *mean score* chi-square test, which is appropriate for ordinal categorical data (see SAS 2009, Procedure FREQ). The mean number of errors per group, the value of the Mantel-Haenszel chi-square statistic (which has 1 degree of freedom (df) in each case), and the associated P-value are reported below (see Table 4.12).

Table 4.12: Number of Errors for Individual Tasks

Task number and description	Statistic	Group	
		With agents (n =68)	Without agents (n=31)
1. Use spelling or grammar tool to check for errors	Mean Chi-square P-value	0.18 0.0342 0.8534	0.16
2. Change lines to bold and italics, font size 20, align to the right	Mean Chi-square P-value	0.59 1.5965 0.2064	0.84
3. Change font face to Arial black, font and colour to dark blue	Mean Chi-square P-value	0.12 16.1784 **< 0.0001**	0.61
4. Insert the word ***course*** after the word ***literacy***	Mean Chi-square P-value	0.24 4.1257 **0.0422**	0.58

5. Insert blank line, insert picture, align picture	Mean Chi-square P-value	0.35 24.0093 < **0.0001**	1.19
6. Delete sentence, undo delete, redo delete	Mean Chi-square P-value	0.28 15.1383 < **0.0001**	1.26
7. Cut highlighted sentence, paste in new paragraph	Mean Chi-square P-value	0.54 5.2260 **0.0223**	0.97
8. Change highlighted block to bullet list, change bullet list to italics	Mean Chi-square P-value	0.18 0.5798 0.4464	0.26
9. Align highlighted line to centre and underline	Mean Chi-square P-value	0.18 4.4914 **0.0341**	0.45
10. Underline highlighted line	Mean Chi-square P-value	0.04 3.8960 **0.0484**	0.16
11. Align block of words to centre, change font size to 22	Mean Chi-square P-value	0.28 5.2044 **0.0225**	0.65

Findings:

The chi-square test results show that eight individual tasks, namely tasks 3, 4, 5, 6, 7, 9, 10 and 11, were associated with statistically significant differences between participants who used the agents and those who did not. Specifically, the use of agents by test group participants was associated with a significant drop in the mean of number of errors for each of these named tasks. In contrast, the study failed to show statistically significant differences in the mean number of errors for three tasks, namely tasks 1, 2 and 8; although for tasks 2 and 8 the average number of errors was lower for the test group than for the control group.

These results imply that $\mathbf{H_{0,\,1}}$ can be rejected for tasks 3, 4, 5, 6, 7, 9, 10 and 11. However, $\mathbf{H_{0,1}}$ cannot be rejected for tasks 1, 2 and 8.

Total Number of Errors

The total number of errors was a count variable for which often the Poisson distribution is an adequate model. However, instead of the Poisson distribution the Negative Binomial distribution was chosen because of the clearly observed over-dispersion present in the count data; this over-dispersion was to be expected since the total error count is the sum of 11 individual error counts which are correlated with each other. Therefore, the total number of errors was analysed using a generalised linear model with Negative Binomial error

distribution and logarithmic link function, fitting group as fixed effect (see SAS 2009, Procedure GENMOD).

In Table 4.13, the mean number of errors per group is reported, together with an estimate and 95% profile likelihood confidence interval for the rate ratio (*with agents*/*without agents*) of errors. Furthermore, the associated likelihood ratio chi-square statistic (1 df) and P-value are presented.

Table 4.13: Total Number of Errors

Statistic	**Group**	
	With agents (n = 68)	**Without agents (n=31)**
Mean	2.97	7.13
Rate ratio	0.417	
95% CI for rate ratio	0.218 to 0.617	
Chi-square	17.83	
P-value	**< 0.0001**	

The results shown in Table 4.13 above indicate that there was a significant difference in the mean total number of errors between the test group and the control group. The estimated rate ratio implies that the average number of errors of the test group was about 58.3% lower relative to the control group, with a 95% confidence interval for the reduction in errors of 38.3% to 88.2%. This result confirms that the participants who worked with the assistance of PIAs made significantly fewer errors in the assessment than those who did not use the agents.

There was a statistically significant difference in the mean total number of errors made by the two groups of participants; therefore, $\mathbf{H_{0,1}}$ can be rejected with respect to the total number of errors.

Factors Influencing Total Number of Errors

The total number of errors was further analysed as before, using a generalised linear model with Negative Binomial error distribution and logarithmic link function. However, in order to investigate the effect of previous computer experience, a two-way model was fitted with the factors group and previous computer experience (yes/no), and the interaction between those two factors. In Table 4.14 the likelihood ratio chi-square statistics (1 df each) and P-values associated with those three model terms are presented.

Table 4.14: Effect of Agents' Assistance and Previous Computer Experience on the Total Number of Errors: Two-Way Model with Interaction Term (n = 99)

Effect	Statistic	
Assessment groups (with | without agents)	Chi-square	18.13
	P-value	**<0.0001**
Previous experience with computers (Yes | No)	Chi-square	4.13
	P-value	0.0421
Interaction effect between assessment group and previous computer experiences	Chi-square	0.13
	P-value	0.7229

The interaction term (see Table 4.14) is not significant; therefore, it was dropped from the model. The likelihood ratio chi-square statistics (1 df each) and P-values associated with the main effects of group and previous experience are presented in Table 4.15 below. Also presented in Table 4.15 are the estimates and the 95% profile likelihood confidence intervals for the rate ratios of errors associated with group (*with agents*/*without agents*) and previous experience (No / Yes).

Table 4.15: Effect of Agents' Assistance and Previous Computer Experience on the Total Number of Errors: Two-Way Model without Interaction Term (n= 99)

Effect	Statistic	
Assessment groups (with | without agents)	Rate ratio	0.418
	95% CI for rate ratio	0.284 to 0.614
	Chi-square	18.25
	P-value	**< 0.0001**
Previous experience with computers (No | Yes)	Rate ratio	1.475
	95% CI for rate ratio	1.016 to 2.140
	Chi-square	4.08
	P-value	**0.0433**

According to the results in Table 4.15, assessment groups had a statistical significant effect P < 0.0001 on total number of errors, as had previous experience P = 0.0433. The estimated rate ratio for assessment groups implies that the average number of errors in the test group is 58.2% lower relative to the participants in the control group, with a 95% confidence interval for reduction in errors of 38.6% to 71.6%. The estimated rate ratio for previous experience implies that the average number of errors for participants without previous experience is

47.5% higher relative to the participants with previous computer experience, with a 95% confidence interval for the increase in errors of 1.6% to 114%.

Findings:
There was a statistically significant effect for assessment groups (i.e. with and without agents) as well as for previous experience with computers. The agents had a potential to enhance participants' performance. Similarly, previous computer experience had a statistically significant effect. Therefore, the results of the two-way model (see Table 4.15) imply that $\mathbf{H_{0,1}}$ can be rejected.

- **Summary: Effectiveness**

The results of the chi-square tests indicated that the reduction of the number of errors for individual tasks was significantly associated with the use of agents. Hence, $\mathbf{H_{0,1}}$ could be rejected for eight individual tasks (tasks 3, 4, 5, 6, 7, 9, 10 and 11), whereas $\mathbf{H_{0,1}}$ could not be rejected for tasks 1, 2 and 8. This indicated that, in general, participants who used agents had a significant drop in terms of number of errors for individual tasks compared to those who did not.

Similarly, the results from the generalised linear model revealed that there was a statistically significant difference in terms of the total number of errors made by the two groups of participants. Thus, $\mathbf{H_{0,1}}$ could be rejected. This also confirmed that participants who worked with agents made significantly fewer total number of errors compared to those who worked without agents. The results from the two-way model for this study also showed that the total number of errors had a strong and significant association with the assessment groups (i.e. with and without agents) and previous experience with computers. This is an encouraging result, as the use of PIAs could be associated with the significant drop in the total number of errors, which broadens the potential of PIAs as alternative tools for improving conventional computer training.

In summary, the results from the chi-square test, the generalised linear model and the two-way model revealed that for both number of errors for individual tasks and the total number of errors, the assessment group that used agents clearly outperformed the group who did not use the agents. The face-to-face interaction with PIAs, the use of natural language by PIAs to

communicate with participants, and the step-by-step feedback (tips) provided by PIAs to guide participants on how to perform tasks, might have contributed to this result.

4.3.1.2 Efficiency

In the context of this study, efficiency referred to the ability to successfully complete a step in a given task, while success meant that a participant managed to get a least one step correct when performing a task. The maximum number of steps in a given task varied, depending on the complexity of the task (see appendix N). Thus, task effort was scored in a binary manner (1 for each successful step or 0 for each step failure). The participants received a score of 1 if they successfully completed at least one step of the task correctly; otherwise they received a score of 0. Thus, the total number of successful steps in a given task was equal to the sum of all individual successful steps while executing that given task.

With regard to the efficiency, the following null-hypothesis was tested:

$H_{0,2}$: *There is no difference in the usability performances in terms of efficiency (task effort) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.*

For each individual task, the proportion of participants who completed at least one step of the task correctly was compared between groups (*with agents* versus *without agents*) using Fisher's exact test (see SAS 2009, Procedure FREQ). Fischer's exact test was used (rather than a conventional chi-square test) because some of the counts of participants who completed the task were equal to 100% of the participants in the given group, or close to 100%.

For each task, number and percentage of participants in each group who completed at least one step of the task correctly are presented in Table 4.16, together with the P-value from Fisher's exact test.

Table 4.16: Comparison of Efficiency in Completing Tasks

Task number and description	Group				P-value
	With agents (N = 68)		Without agents (N = 31)		
	n	%	n	%	
1. Use spelling or grammar tool to check for errors.	56	82.4	26	84.0	1.0000
2. Change lines to bold and italics, font size 20, align to the right.	68	100	29	94.0	0.0959
3. Change font face to Arial black, font and colour to dark blue.	66	97.1	27	87.1	0.0749
4. Insert the word ***course*** after the word ***literacy***.	67	99.0	27	87.1	**0.0323**
5. Insert blank line, insert picture, align picture.	68	100	30	97.0	0.3131
6. Delete sentence, undo delete, redo delete.	62	91.2	20	65.0	**0.0028**
7. Cut highlighted sentence, paste in new paragraph.	66	97.1	25	81.0	**0.0109**
8. Change highlighted block to bullet list, change bullet list to italics.	66	97.1	29	94	0.5873
9. Align highlighted line to centre and underline.	66	97.1	25	81.0	**0.0109**
10. Underline highlighted line.	65	96.0	26	84.0	0.1038
11. Align block of words to centre, change font size to 22.	62	91.2	22	71.0	**0.0148**

Findings:

Among the 11 tasks shown in Table 4.16, Fisher's exact test was found to be statistically significant for the following five tasks, namely 4, 6, 7, 9 and 11. For these five tasks, there was a statistically significant difference between the groups in the proportions of participants who completed at least one step of the task successfully. These differences were greater than 10% points, specifically 26.2% for task 6, 20.2% for task 11, and 16.1% for tasks 7 and 9. The difference in task 4 was 12.0%. Although Fisher's exact test is not statistically significant for tasks 1, 2, 3, 5, 8 and 10, the percentage differences for five of the six tasks were in favour of the test group, that is, the proportion of participants who completed at least one step of the task successfully was higher for the test group than for the control group.

These results imply that $\mathbf{H_{0,2}}$ can be rejected for tasks 4, 6, 7, 9 and 11, but cannot be rejected for tasks 1, 2, 3, 5, 8 and 10.

Factors Influencing Task Effort

The association between *level of education* and efficiency (task effort), adjusted for the use of agents, was analysed using Fisher's exact test for stratified 2×2 tables. For this purpose, level of education was categorised into two categories, namely *highest qualification is at least matric (grade 12)* versus *highest qualification is below matric* (grade 11, grade 10 or grade 9). For each of the 11 tasks listed in Table 4.16 above, the association between the binary variable *level of education* and task effort was assessed, after stratification by the variable *Group* (with agents / without agents). In Table 4.17 below, for each task the P-value associated with the null hypothesis of no association between level of education and task effort is presented.

Table 4.17: Association of Level of Education with Efficiency (Task Effort)

Task number and description	P-value
1. Use spelling or grammar tool to check for errors.	0.6135
2. Change lines to bold and italics, font size 20, align to the right.	0.8368
3. Change font face to Arial black, font and colour to dark blue.	1.0000
4. Insert the word ***course*** after the word ***literacy***.	0.4490
5. Insert blank line, insert picture, align picture.	1.0000
6. Delete sentence, undo delete, redo delete.	**0.0290**
7. Cut highlighted sentence, paste in new paragraph.	**0.0373**
8. Change highlighted block to bullet list, change bullet list to italics.	0.6008
9. Align highlighted line to centre and underline.	0.2020
10. Underline highlighted line.	0.4961
11. Align block of words to centre, change font size to 22.	0.0597

Findings:

Among the 11 tasks presented in Table 4.17, Fisher's exact test was found to be statistically significant only for two tasks, namely 6 and 7. The test was not statistically significant for the remaining seven tasks 1, 2, 3, 4, 5, 8, 10 and 11. These results imply that $\mathbf{H_{0,\,2}}$ can be rejected for tasks 6 and 7, but cannot be rejected for tasks 1, 2, 3, 4, 5, 8, 10 and 11. Based on this finding, it can be concluded that in general, for most of the tasks (i.e. 9 tasks out of 11) there was no association between level of education and efficiency (task effort).

Similarly, the association between age group and efficiency (task effort), adjusted for the use of agents, was analysed using Fisher's exact test for stratified 2×2 tables. Here, age was categorised into two categories, namely *age 30 years or below* versus *age above 30 years*.

For each of the 11 tasks listed in Table 4.16, the association between the binary variable *age group* and task effort was assessed, after stratification by the variable *Group* (with agents / without agents). In Table 4.18 below, for each task the P-value associated with the null hypothesis of no association between age group and task effort is presented.

Table 4.18: Association of Age Group with Efficiency (Task Effort)

Task number and description	P-value
1. Use spelling or grammar tool to check for errors.	0.4470
2. Change lines to bold and italics, font size 20, align to the right.	1.0000
3. Change font face to Arial black, font and colour to dark blue.	0.8575
4. Insert the word ***course*** after the word ***literacy***.	0.2039
5. Insert blank line, insert picture, align picture.	0.4828
6. Delete sentence, undo delete, redo delete.	1.0000
7. Cut highlighted sentence, paste in new paragraph.	0.7081
8. Change highlighted block to bullet list, change bullet list to italics.	0.6500
9. Align highlighted line to centre and underline.	0.8316
10. Underline highlighted line.	0.0627
11. Align block of words to centre, change font size to 22.	0.0970

Findings:

Table 4.18 shows that there were no statistically significant findings for all 11 performed tasks. These results imply that $\mathbf{H_{0,2}}$ cannot be rejected for all 11 tasks. Based on this, it can be concluded that no significant association was found between age group and efficiency (task effort).

Summary: Efficiency

The results of Fischer's exact test for this study demonstrated that there was a significant difference between the groups of participants who used PIAs and those who did not for five individual tasks (tasks 4, 6, 7, 9 and 11). It was also found that no significant difference existed between these two groups with regard to tasks 1, 2, 3, 5, 8 and 10. Consequently, $\mathbf{H_{0,2}}$ could be rejected in the case of tasks 4, 6, 7, 9 and 11, whereas $\mathbf{H_{0,2}}$ could not be rejected for tasks 1, 2, 3, 5, 8 and 10.

Although $\mathbf{H_{0,2}}$ could not be rejected for the six latter tasks, for five of these six tasks, higher proportions of participants who used PIAs achieved higher scores than those who did not used the PIAs. This result might have been caused, in part, by the fact that almost all

participants (91%) had some kind of previous interaction experience with agents, and most of them (83%) had a very positive outlook on a human being's roles played by agents. Possibly their positive attitudes toward PIAs made them feel comfortable, and increased their motivation and engagement while using PIAs. This could further have made it easier for them to better comprehend, recall and be able to use the step by step task-related feedback provided by PIAs that guided them to performing their tasks correctly.

The test results presented in Table 4.17 also revealed that there was no significant association between participants' level of education and efficiency (task effort) for most tasks (9 out of the 11 tasks performed). Similarly, the participants' age group had no significant effect on their efficiency for any of the 11 tasks (Table 4.18). These results suggest that a participant's level of education or age group generally has no significant effect on his/her efficiency when using PIAs. This finding was an unexpected, but inspiring result, as level of education or age group are then not necessarily a requirement for using PIAs, which broadens the possibilities of PIAs as tools for facilitating or supporting learning for people with different education levels and from different age groups.

4.4 Post-Test Questionnaire Analysis

All study participants completed a post-test questionnaire indicating their satisfaction levels concerning the systems they used during the user testing and their participation in the study. For the purpose of this study, two types of post-test questionnaires were used. One questionnaire was used with the test group participants (see Appendix L) and another with the control group participants (see Appendix M).

The questions about satisfaction level had the purpose of measuring study participants' subjective opinions in terms of their satisfaction with: (i) the respective systems that they used during user testing (PIAs incorporated in SMOS for the test group participants, and MS Word for control group participants), and (ii) the satisfaction levels with regard to their participation in the study.

In contrast to the performance data, the analysis of the post-test questionnaire data included the four participants in the test group who did not have performance data. Since these four participants worked with agents, they could (and did) report their experiences with the agents.

Thus, the data of 31 participants in the control group and 72 participants in the test group was available.

The following subsections present statistical analysis results related respectively to the study participants' subjective opinions in terms of their satisfaction levels with the respective systems they used during user testing (subsection 4.4.1), and about the satisfaction levels with regard to their participation in the study (subsection 4.4.2).

4.4.1 Satisfaction Levels with the Systems Used

This section presents the results on what study participants (i.e. control and test group) thought of the respective systems that they used during user testing. The data related to the control group participants is presented first, and afterwards the test group's data will be discussed.

4.4.1.1 Satisfaction Levels with the MS Word Environment

The control group participants used the MS Word 2007 word processor to perform their user testing tasks. A Likert scale questionnaire was used to collect participants' opinions on MS Word. The Likert scale questionnaire comprised five response options to the various statements: strongly disagree, disagree, not sure, agree and strongly agree. Participants could choose one of these five options to rate their opinions on the statements. For purpose of statistical summaries, the five response options were scored from 1 for *strongly disagree* to 5 for *strongly agree*.

Table 4.19 summarises the data from the control group post-test questionnaire (questions 1 to 23 in Appendix M). The questions displayed in Table 4.19 are grouped in three categories, namely learning content, effectiveness, and satisfaction levels. Although Table 4.19 includes questions about learning content and efficiency, it forms part of this discussion as the questionnaires were used to determine satisfaction.

In Table 4.19, descriptive statistics (mean, and standard deviation (STD)) for the scores of each questionnaire statement are presented; furthermore, the proportions of the control group participants responding with either *strongly disagree* (SD), *disagree*(D), *not sure* (NS), *agree* (A), *strongly agree* (SA) and the sum of A & SA, are also listed. The researcher used the sum

of A and SA to analyse and compare the control group participants' opinions about each of the statements listed in Table 4.19 below.

Table 4.19: Satisfaction with MS Word Environment

Category	Statement	N	SD	D	NS	A	SA	Sum of A & SA	Mean	STD
Learning Content	Microsoft Word had functionalities I expected it to have.	31	1	2	1	14	13	27	4.16	1.00
			3.2%	6.5%	3.2%	45.2%	41.9%	87.1%		
	Microsoft Word environment was easy to use.	31	0	3	1	14	13	27	4.19	0.91
			0.0%	9.7%	3.2%	45.2%	41.9%	87.1%		
Effectiveness of the MS Word	I found the Microsoft Word help function to be useful.	31	3	0	1	11	16	27	4.19	1.19
			9.7%	0.0%	3.2%	35.5%	51.6%	87.1%		
	Microsoft Word help function provided me with all the necessary information.	31	1	1	2	13	14	27	4.23	0.96
			3.2%	3.2%	6.5%	41.9%	45.2%	87.1%		
	Microsoft Word help function helped me to quickly learn how to perform a particular task.	30	1	0	1	13	15	28	4.37	0.85
			3.3%	0.0%	3.3%	43.3%	50.0%	93.3%		
	Microsoft Word help function helped me to recall the different steps involved for a particular task.	30	0	1	0	17	12	29	4.33	0.66
			0.0%	3.3%	0.0%	56.7%	40.0%	96.7%		
	Microsoft Word help function helped me to complete my tasks quicker.	31	0	2	3	9	17	26	4.32	0.91
			0.0%	6.5%	9.7%	29.0%	54.8%	83.9%		
	Microsoft Word help function was very practical.	29	0	1	1	14	13	27	4.34	0.72
			0.0%	3.5%	3.5%	48.3%	44.8%	93.1%		
	Microsoft Word help function assisted me to identify my mistakes when performing a task.	31	1	0	2	13	15	28	4.32	0.87
			3.2%	0.0%	6.5%	41.9%	48.4%	90.3%		
	With Microsoft Word help function, it was quicker and easier for me to recover from a mistake.	29	1	1	0	15	12	27	4.24	0.91
			3.5%	3.5%	0.0%	51.7%	41.4%	93.1%		
	I was able to understand the concepts better with the Microsoft Word help function than I would have without them.	31	0	1	1	14	15	29	4.39	0.72
			0.0%	3.2%	3.2%	45.2%	48.4%	93.6%		

	With the help of Microsoft Word help function I have managed to develop new abilities.	31	1	0	0	12	18	30	4.48	0.81
			3.2%	0.0%	0.0%	38.7%	58.1%	96.8%		
	Microsoft Word help function helped me to feel more confident about my computer skills.	30	1	0	1	7	21	28	4.57	0.86
			3.3%	0.0%	3.3%	23.3%	70.0%	93.3%		
	I trusted the hint from Microsoft Word help function.	28	1	0	1	13	13	26	4.32	0.86
			3.6%	0.0%	3.6%	46.4%	46.4%	92.9%		
Satisfaction	The interactions with Microsoft Word were easy.	31	0	1	3	15	12	27	4.23	0.76
			0.0%	3.2%	9.7%	48.4%	38.7%	87.1%		
	I was able to use Microsoft Word successfully.	31	0	1	0	16	14	30	4.39	0.67
			0.0%	3.2%	0.0%	51.6%	45.2%	96.8%		
	I felt frustrated working with Microsoft Word.	29	9	8	5	4	3	7	2.45	1.35
			31.0%	27.6%	17.2%	13.8%	10.3%	24.1%		
	I felt nervous when working with Microsoft Word.	30	11	10	3	6	0	6	2.13	1.14
			36.7%	33.3%	10.0%	20.0%	0.0%	20.0%		
	I really had to concentrate to work with Microsoft Word.	31	1	1	2	15	12	27	4.16	0.93
			3.2%	3.2%	6.5%	48.4%	38.7%	87.1%		
	It was exciting working with Microsoft Word.	28	0	1	1	9	17	26	4.50	0.75
			0.0%	3.6%	3.6%	32.1%	60.7%	92.9%		
	Working with Microsoft Word made me change my attitude towards computers.	31	1	1	1	12	16	28	4.32	0.94
			3.2%	3.2%	3.2%	38.7%	51.6%	90.3%		
	My experience with Microsoft Word encouraged me to learn about other computer programs.	30	1	0	0	9	20	29	4.57	0.82
			3.3%	0.0%	0.0%	30.0%	66.7%	96.7%		
	Based on my experience with Microsoft Word, I can encourage my friends to learn about new concepts.	31	1	0	0	6	24	30	4.68	0.79
			3.2%	0.0%	0.0%	19.4%	77.4%	96.8%		

Note: N: number of respondents

The categories (left hand column in Table 4.19) will be discussed next.

Learning content:

A substantial proportion (87.1%) of control group participants strongly agreed / agreed to both statements: (i) MS Word had functionalities that they expected it to have, and (ii) the MS Word environment was easy to use.

Effectiveness of MS Word:

A substantial proportion of participants (96.8%) respectively strongly agreed / agreed that they have managed to develop new abilities with MS Word help. Furthermore, 96.7% of them strongly agreed / agreed that the MS Word help function assisted them to recall the different steps involved for a particular task. It was noted that a considerable proportion of participants also strongly agreed / agreed to each of the following statements regarding the MS Word help function:

- They were able to better understand the concepts with the help function than they would have without it (93.6%),
- It helped them to feel more confident about their computer skills (93.3%),
- It helped them to quickly learn how to perform a particular task (93.3%),
- It was very practical, and with its help, it was quicker and easier to recover from mistakes (93.1%),
- They trusted its hints (92.9%),
- It assisted them to identify their mistakes when performing a task (90.3%),
- They found it useful and it provided them with the necessary information (87.1%), and
- It helped them to quicker complete their tasks (83.9%).

Satisfaction:

Almost all participants (96.8%) in the control group strongly agreed / agreed that they were able to use MS Word successfully and, based on their experience with MS Word, they could encourage their friends to learn new concepts (96.8%) and to learn about other computer programs (96.7%).

Most participants (92.9%) in the control group strongly agreed / agreed that it was exciting working with MS Word, that it changed their attitudes towards computers (90.3%), and that the interactions with MS Word were easy (87.1%).

On the other hand, 87.1% of participants strongly agreed / agreed that they really had to concentrate to work with MS Word, 24.1% were frustrated, while 20.0% were nervous when working with MS Word.

Findings:

As per the statements listed in Table 4.19, the best ratings of control group participants with regard to the learning content provided by MS Word, were in terms of the functionalities that they expected it to have, and that MS Word was easy to use.

Furthermore, the highest ratings with regard to the effectiveness of MS Word were in terms of managing to develop new abilities with the MS Word help function, helping them to recall the different steps involved for a particular task, enabling them to better understand certain concepts, quickly learning how to perform a particular task, and being more confident about their computer skills. The MS Word help function was perceived to be very practical and it was quicker and easier for these participants to recover from a mistake.

The experience of using MS Word, as perceived by control group participants, was such that the participants could use MS Word successfully, that they would encourage their friends to learn new concepts, that the experience changed their attitudes towards other computer programs and motivated them to learn more, and that they were excited working with MS Word.

- **Control Group Participants' Satisfaction Levels based on Computer Experience**

An independent-sample t-test was conducted to compare the satisfaction levels on the MS Word environment for control group participants who had computer experience and those who did not. The results of the comparison are presented in Table 4.20.

Table 4.20: Comparison of Satisfaction Levels Based on Computer Experience

Statistic	**Computer Experience**	
	Yes (N = 17)	**No (N=14)**
Mean	36.35	33.35
SD	5.80	4.16
Mean difference (***Yes – No***)	3.00	
95% CI for mean difference	- 0.80 to 6.78	
T statistic	1.616	
P-value	**0.117**	

Findings:

The results summarised in Table 4.20 suggest that, although mean satisfaction levels on the MS Word environment in the subgroup with computer experience were somewhat higher than in the subgroup without computer experience, this difference was not statically significant. The magnitude of the effect size was moderate (eta squared = 0.082).

This finding implies that control group participants' computer experience had no significant effect on their satisfaction levels. Therefore, the study has failed to show that the satisfaction levels on MS Word differed between control group participants who had computer experiences and those who did not.

- **Summary: Satisfaction Levels with the MS Word Environment**

Concerning system satisfaction participants stated that, with regard to learning content, the MS Word environment was relatively easy to use and had functionalities they expected it to have. Regarding MS Word effectiveness, participants stated that with the assistance of the MS Word help function they managed to develop new skills and the function helped them to recall the different steps involved for a particular task. Lastly, concerning satisfaction with MS Word, participants stated that MS Word was easy to use and that they would encourage their friends to learn new concepts and learn about other computer programs.

The following responses by control group participants in the post-test questionnaire, namely that the MS Word environment was relatively easy to use, that its help function helped them to recall the different steps involved for a particular task, and that it was easy for them to use MS Word successfully, were consistent with the finding that participants performed relatively well in terms of the tasks given to them during the user test (as discussed earlier), despite some feelings of frustration and nervousness, as well as high requirement of concentration.

In the next section, data related to the test group participants' satisfaction levels will be examined.

4.4.1.2 Satisfaction Levels with the PIAs

The test group participants used a variety of PIAs to assist them in performing their user testing tasks. Similar to the control group (see subsection 4.4.1.1), a Likert scale questionnaire was used in order to collect test group participants' opinions regarding the agents they used. The statements in the Likert scale questionnaire allowed for response options, namely strongly disagree, disagree, not sure, agree, and strongly agree. Test group participants could choose one of these five response options to rate their opinions on agents. For purpose of statistical summaries, the five response options were scored from 1 for *strongly disagree* to 5 for *strongly agree*.

Table 4.21 summarises the data of the test group post-test questionnaire (questions 1 to 25 in Appendix L). The questions again are divided into three categories, namely learning content, effectiveness, and satisfaction levels. In Table 4.21 (similar to Table 4.19) descriptive statistics (mean, and standard deviation (STD)) based on the scores for each statement are reported; furthermore, the proportions of test group participants responding with either *strongly disagree* (SD), *disagree*(D), *not sure* (NS), *agree* (A), *strongly agree* (SA) and the sum of A and SA are listed. Again, the sum of A and SA was used to analyse and to compare the test group participants' personal opinions on each of the statements concerning PIAs and the use thereof.

Table 4.21: Satisfaction with Agents

Category	Statement	N	SD	D	NS	A	SA	Sum of A and SA	Mean	STD
Learning content	The agents had functions and capabilities I expected it to have.	71	3	1	10	31	26	57	4.07	0.98
			4.2%	1.4%	14.1%	43.7%	36.6%	80.3%		
	The agents used a language that was familiar to me.	71	2	6	2	26	35	61	4.21	1.04
			2.8%	8.5%	2.8%	36.6%	49.3%	85.9%		
Effectiveness of the Agents	The agents' hints provided all the necessary information.	71	1	6	4	23	37	60	4.25	1.00
			1.4%	8.5%	5.6%	32.4%	52.1%	84.5%		
	The agents' hints helped me to quickly learn how to perform a particular task.	72	0	0	1	37	34	71	4.46	0.53
			0.0%	0.0%	1.4%	51.4%	47.2%	98.6%		
	The agents' hints helped to recall the different steps involved for a particular task.	71	1	0	6	32	32	64	4.32	0.75
			1.4%	0.0%	8.5%	45.1%	45.1%	90.1%		
	The agents' hints helped me to complete my tasks quicker.	70	0	4	8	25	33	58	4.24	0.88
			0.0%	5.7%	11.4%	35.7%	47.1%	82.9%		
	The agents' hints were very practical.	68	0	3	7	36	22	58	4.13	0.77
			0.0%	4.4%	10.3%	52.9%	32.4%	85.3%		
	The agents' hints assisted me to identify my mistakes when performing a task.	70	3	3	8	31	25	56	4.03	1.02
			4.3%	4.3%	11.4%	44.3%	35.7%	80.0%		

	With the agents, it was quicker and easier for me to recover from a mistake.	70	0	7	5	32	26	58	4.10	0.92
			0.0%	10.0%	7.1%	45.7%	37.1%	82.9%		
	I was able to understand the concepts better with the agents than I would have without them.	72	3	9	8	27	25	52	3.86	1.15
			4.2%	12.5%	11.1%	37.5%	34.7%	72.2%		
Satisfaction	With the help of the agents I have managed to develop new abilities.	68	0	4	5	29	30	59	4.25	0.84
			0.0%	5.9%	7.4%	42.7%	44.1%	86.8%		
	The interactions with the agents were easy.	72	0	1	9	38	24	62	4.18	0.70
			0.0%	1.4%	12.5%	52.8%	33.3%	86.1%		
	I was able to use agents successfully.	69	0	0	2	26	41	67	4.57	0.56
			0.0%	0.0%	2.9%	37.7%	59.4%	97.1%		
	I trusted the advice from agents.	71	0	0	2	30	39	69	4.52	0.56
			0.0%	0.0%	2.8%	42.3%	54.9%	97.2%		
	I found the agents to be intelligent.	71	0	0	7	29	35	64	4.39	0.67
			0.0%	0.0%	9.9%	40.9%	49.3%	90.2%		
	I found the agents to be friendly.	69	3	3	8	20	35	55	4.17	1.08
			4.4%	4.4%	11.6%	29.0%	50.7%	79.7%		
	I felt frustrated working with the agents.	70	29	21	9	6	5	11	2.10	1.24
			41.4%	30.0%	12.9%	8.6%	7.1%	15.7%		
	I felt nervous when working with the agents.	69	26	21	6	13	3	16	2.22	1.26
			37.7%	30.4%	8.7%	18.8%	4.4%	23.2%		
	I really had to concentrate to work with the agents.	67	1	5	4	33	24	57	4.10	0.92
			1.5%	7.5%	6.0%	49.3%	35.8%	85.1%		
	It was exciting working with the agents.	70	0	2	2	32	34	66	4.40	0.69
			0.0%	2.9%	2.9%	45.7%	48.6%	94.3%		
	The agents' hints helped me to feel more confident about my computer skills.	71	0	0	3	26	42	68	4.55	0.58
			0.0%	0.0%	4.2%	36.6%	59.2%	95.8%		
	Working with the agents made me change my attitude towards computers.	70	1	1	6	31	31	62	4.29	0.80
			1.4%	1.4%	8.6%	44.3%	44.3%	88.6%		
	My experience with these agents encouraged me to find out more about them.	71	0	1	7	28	35	63	4.37	0.72
			0.0%	1.4%	9.9%	39.4%	49.3%	88.7%		
	Based on my experience with the agents, I can encourage my friends to use them when learning about new concepts.	72	0	0	4	18	50	68	4.64	0.59
			0.0%	0.0%	5.6%	25.0%	69.4%	94.4%		

	I would like to consider using agents when learning other concepts in real life.	72	1	2	6	26	37	63	4.33	0.86
			1.4%	2.8%	8.3%	36.1%	51.4%	87.5%		

Note: N: number of respondents

The categories (left hand column in Table 4.21) will now be discussed.

Learning content:

A large proportion of the test group participants (85.9%) strongly agreed / agreed that the agents used a language that was familiar to them. Similarly, 80.3% of participants strongly agreed / agreed that the agents had functions and capacities they expected them to have.

Effectiveness of the agents:

With regard to the effectiveness of the agents, the majority of test group participants strongly agreed / agreed to each of the following statement about the agents' hints:

- They helped to quickly learn how to perform a particular task (98.6%),
- They helped to recall the different steps involved for a particular task (90.1%),
- They were very practical (85.3%),
- They provided all the necessary information (84.5%),
- They helped to complete the tasks quicker (82.9%), and
- They assisted in identifying mistakes when performing a task (80.0%).

Furthermore, 86.1% of the test group participants strongly agreed / agreed that they managed to acquire new skills with the help of the agents, that it was quicker and easier to recover from a mistake with the help of an agent (82.9%), and lastly, that they were able to better understand the concepts with the help of the agents compared to without them (72.2%).

Satisfaction:

Almost all test group participants (97.2%) strongly agreed / agreed that they trusted the advice from agents, that they were able to use the agents successfully (97.1%), and that the agents' hints helped them to feel more confident about their computer skills (95.8%). A total of 94.4% of participants strongly agreed / agreed that they would encourage friends to use agents when learning new concepts, 94.3% stated that it was exciting working with the agents, while 90.2% found the agents to be intelligent.

A high proportion of test group participants (88.7%) strongly agreed / agreed that their experience with agents encouraged them to find out more about them, that working with agents changed their attitudes towards computers (88.6%), that they would consider using agents when learning concepts in real life, found the interaction with agents easy (86.1%), and basically perceived the agents as being friendly (79.7%).

On the negative side, 85.1% of the test participants strongly agreed / agreed that they really had to concentrate in order to be able to work with the agents, 23.2% felt nervous working with the agents, and 15.7% were frustrated by the agents.

Findings:

The results listed above suggest that the fact that the agents used language that was familiar to the test participants was most important to them in terms of the learning content provided by agents. With regard to the effectiveness of the agents, participants emphasised that the agents' hints helped them to quickly learn how to perform a particular task, as well as to recall the different steps involved for a particular task. The data in Table 4.21 further shows that the highest satisfaction levels, as perceived by test group participants, were achieved for the following aspects: trusting the advice from agents, using agents successfully, feeling more confident about their computer skills as a result of agent hints, encouraging their friends to use agents when learning new concepts, and being excited when working with agents.

Using the satisfaction questionnaire, test group participants were asked about their preference for individual agents, their levels of enjoyment and liking of the agents.

Preference Regarding Individual Agents

Table 4.22 presents a summary of the data about participants' preferences (questions 26 to 29 in Appendix L) regarding the type of agents that they used.

Table 4.22: Preferences for the Agent Types

Statement	N	Response = *Yes*	
		n	%
I prefer a male agent to a female agent.	68	33	49.0%
I prefer a cartoon agent to a realistic agent.	65	33	51.0%
I prefer a dog agent to a human agent.	69	29	42.0%
I prefer a text agent to a text and audio agent.	68	31	46.0%

Note: N: number of respondents and n: number of respondents who selected *Yes*

Findings:

The results summarised in Table 4.22 suggest that there were only small differences with regard to the number of test group participants who preferred a cartoon agent to a realistic agent, and a male agent to a female agent.

Enjoyment Levels pertaining to Agents

Table 4.23 below summarises the participants' enjoyment of the various agents they used (question 33 in Appendix L).

Table 4.23: Enjoyment of Agents

Agents	N	Response = *Enjoyable*	
		n	%
Female text agent (Agent 1)	63	50	79.4%
Male text agent (Agent 2)	62	45	73.0%
Female text & audio (Agent 3)	61	**56**	**92.0%**
Male text & audio (Agent 4)	61	51	84.0%
Female cartoon human (Agent 5)	62	52	84.0%
Male cartoon human (Agent 6)	60	51	85.0%
Female cartoon dog (Agent 7)	67	57	85.0%
Male cartoon dog (Agent 8)	62	57	**92.0%**
Female realistic dog (Agent 9)	64	53	83.0%
Male realistic dog (Agent 10)	62	**59**	**95.2%**

Note: N: number of respondents and n: number of respondents who selected *enjoyable* option.

Data depicted in Table 4.23 on the participants' enjoyment with regard to the agents suggest the following:

- Ninety-five per cent of participants enjoyed working with the male realistic dog agent.
- Ninety-two per cent of participants found working with both the female text & audio and the male cartoon dog agent enjoyable.
- Eighty-five per cent of participants also found both the female cartoon dog agent and the male cartoon human agent enjoyable when working with them.
- Eighty-four per cent of participants indicated that they enjoyed working with the male text & audio agent as well as the female cartoon human agent.
- Eighty-three per cent of participants enjoyed working with the female realistic dog agent.
- Seventy-nine per cent of participants found working with the female text agent enjoyable.
- Seventy-three per cent of participants found working with the male text agent enjoyable.

Findings:

The results above suggest that the agent most enjoyed by test group participants was the male realistic dog. This was followed by the male cartoon dog and the female text & audio agent.

Preferring Specific Agents

Participants indicated their levels of preference in terms of the 10 agents with respect to three attributes, namely appearance, voice and movement.

Preference of Agents' Attributes

The data on the participants' preference of the agents in terms of the attributes of appearance, voice and movement (questions 30 to 32 in Appendix L) are shown in Table 4.24.

Table 4.24: Preference: Agents' Attributes

Agent	Attribute					
	Appearance (N = 56)		Voice (N = 62)		Movement (N = 44)	
	n	%	n	%	n	%
Female text agent (Agent 1)	**11**	**20.0**	7	11.3	2	5.0
Male text agent (Agent 2)	5	9.0	9	15.0	2	5.0
Female text & audio (Agent 3)	6	11.0	**11**	**18.0**	3	7.0
Male text & audio(Agent 4)	5	9.0	4	7.0	3	7.0
Female cartoon human (Agent5)	5	9.0	5	8.1	**10**	**23.0**
Male cartoon human (Agent 6)	5	9.0	7	11.3	4	9.1
Female cartoon dog (Agent 7)	4	7.1	5	8.1	5	11.3
Male cartoon dog (Agent 8)	9	**16.1**	**10**	**16.1**	**7**	**16.0**
Female realistic dog (Agent 9)	4	7.1	2	3.2	2	5.0
Male realistic dog (Agent 10)	2	4.0	2	3.2	6	14.0

Note: N: number of respondents and n: number of respondents who selected a particular criterion (i.e. Appearance, Voice and Movement).

Referring to the table above the following was noticed:

- The female text agent was the most liked agent in terms of appearance (20.0% of participants selected this option). This was followed by the male cartoon dog agent (16.1%). The agent least liked in terms of appearance was the male realistic dog agent.
- The most liked agent in terms of voice was the female text and audio agent (18.0% of participants chose this option). The second most liked agent in terms of voice was the male cartoon dog agent (16.1%). The two least liked agents in terms of voice were the male realistic dog agent (3.2%) and the female realistic dog agent (3.2%).

- The agent liked most based on movement was the female cartoon human agent (23% of participants chose this option). The second most liked agent in terms of movement was the male cartoon dog agent (16.0%), followed by the male realistic dog agent (14.0%). In terms of movement the least liked agents was the male text agent (5.0%), the female text agent (5.0%), and the female realistic dog agent (5.0%).

Findings:

The results above suggest that the most liked agents, as selected by test group participants, were the following:

- Female text agent and male cartoon dog were the two most liked agents in terms of their appearance.
- Female text & audio agent and male cartoon dog were the two most liked agents in terms of their voice.
- Female cartoon human and male cartoon dog were the two most liked agents in terms of their movement.

Overall Preference of Agents

Participants were asked to provide their individual overall preference with regard to the 10 agents they used (question 34 in Appendix L). Table 4.25 below summarises this. This overall preference is based on three attributes (appearance, voice and movement) as shown in Table 4.24.

Table 4.25: Agents Overall Preference

	Overall Preference (N = 69)	
Agents	**n**	**%**
Female text agent (Agent 1)	9	**13.1**
Male text agent (Agent 2)	6	9.0
Female text & audio (Agent 3)	8	**12.0**
Male text & audio (Agent 4)	5	7.3
Female cartoon human (Agent 5)	7	10.1
Male cartoon human (Agent 6)	7	10.1
Female cartoon dog (Agent 7)	6	9.0
Male cartoon dog (Agent 8)	15	**22.0**
Female realistic dog (Agent 9)	2	3.0
Male realistic dog (Agent 10)	4	6.0

Note: N: number of respondents and n: number of respondents who selected a particular agent across all three attributes (appearance, voice and movement).

The results in Table 4.25 show that the most popular agent, chosen by 22.0% of the participants, was the male cartoon dog agent. This was followed by the female text agent (13.1%), the female text & audio agent (12.0%), and both the female cartoon human agent and the male cartoon human agent (each chosen by 10.1% of participants). The female cartoon dog and male text agent were each chosen by 9.0% of the participants. The male text & audio agent, the male realistic dog agent, and the female realistic dog agent were the three least popular agents having respectively 7.3%, 6.0% and 3.0% of the support.

Findings:

The results above suggest that the overall preferred agents as selected across all three criteria (appearance, voice and movement) by test group participants were the male realistic dog agent, the female text agent, and the female text & audio agent.

Association of Gender with Choice of Agents

Fisher's exact test was performed to determine if there was a significant association between the gender of test group participants and the preferred gender of the agent. The relevant results are shown in Table 4.26 below.

Table 4.26: Participants' Gender and Preferred Gender of Agent

Statistic	Participants' Gender	
	Male (N=28)	Female (N=40)
Participants who prefer male agent		
n	16	17
%	57.0	43.0
P-value	0.3246	

Note: N: number of respondents as per their gender and n: number of respondents who prefer selected male agent

Findings:

Table 4.26 shows that 57.0% of male participants prefer a male agent, while only about 43% of female participants prefer a male agent. However, the result of Fisher's exact test displayed in Table 4.26 shows that this difference is not statistically significant (P = 0.3246).

Thus, there was no significant difference between the proportion of test group male participants who preferred a male agent to a female agent and the proportion of female

participants who preferred a male agent to a female agent. This means that the test group participants' gender has no significant effect on their preference (choice) of agents' gender.

Test Group Participants' Satisfaction Levels Based on Computer Experience

An independent-samples t-test was conducted to compare the satisfaction levels regarding the agents for test group participants who had computer experiences and those who did not. The results of the t-test are shown in Table 4.27.

Table 4.27: Comparison of Satisfaction Based on Computer Experience

Statistic	Computer Experience	
	Yes (N=37)	**No (N=35)**
Mean	57.83	55.57
SD	5.83	6.61
Difference (*Yes – No*)	2.26	
T	1.544	
95% CI	-0.66 to 5.19	
P-value	**0.127**	

Note: N: number of respondents as per their computer experience

Findings:

The results suggest that there was only a small, and statistically not significant, difference between test group participants who had computer experience and those who did not in terms of their satisfaction levels regarding agents (P = 0.127; eta squared = 0.032). Therefore, the results in Table 4.27 suggest that computer experience has no effect on the test group participants' levels of satisfaction.

Summary: Satisfaction Levels with the PIAs

Concerning learning content, participants using PIAs stated that the agents used a language that was familiar to them. In relation to the agents' effectiveness, this group of participants stated that the agents' hints helped them to quickly learn how to perform a particular task and to recall the various steps required. Regarding agent satisfaction, the test participants stated that they trusted the advice from the agents, were able to use agents successfully, and felt more confident about their computer skills.

These results are consistent with the fact that these participants performed well in terms of their user tasks during usability testing (as discussed earlier).

Small differences were found in terms of participants' preference regarding individual agents. Also, slight differences were found among participants concerning their enjoyment of agents, including agents' attributes such as voice, appearance and movement. For example, in this study the male cartoon dog agent, based on its appearance, voice and movement, was the overall favourite of test participants. Despite the fact that the participants chose one agent above the other in the questionnaire, they were still able to use most of the agents to perform their user test tasks during usability testing (as discussed earlier).

4.4.2 Study Satisfaction Levels

This section presents statistical analysis results on the participation satisfaction levels of study participants from both groups (i.e. control and test groups). The following null hypothesis was formulated in order to compare the study satisfaction levels of both groups:

$H_{0,3}$: *There is no difference in the user satisfaction in terms of amount learnt from the study overall, enjoyment of being part of the study, and willingness to participate in a similar study in future when using PIAs in adult computer literacy training compared to using conventional computer training techniques.*

With regard to the above-stated null hypothesis, a series of tests were conducted to compare the study satisfaction levels of participants from test and control groups. The focus of these comparative statistical tests was the following: (i) how many participants from both groups enjoyed being part of the study, (ii) how much they learnt from the study overall, and (iii) if they would like to participate in a similar study in future. The results of each of these statistical comparative tests will now be discussed.

4.4.2.1 Association of Group and Amount Learnt from the Study Overall

In the context of this study, the term *amount learnt* refers to the computer skills that participants acquired during this study. An independent-samples t-test was conducted to compare the mean scores of the variable *amount learnt from the study overall* between the test (question 40 in Appendix L) and control groups (question 28 in Appendix M). The results of the t-test are shown in Table 4.28.

Table 4.28: Amount Learned from the Study Overall

Statistic	Group	
	With agents (N = 72)	**Without agents (N = 31)**
Mean	1.26	1.20
SD	0.640	0.484
Difference	0.06	
t statistic	0.439	
95% CI	-0.20 to 0.32	
P-value	**0.662**	

Note: N: number of respondents as per their group

Findings:

The results summarised in Table 4.28 show that there was no statistically significant difference between the two groups in terms of the perceived amount learnt from the study overall.

Thus, according to the study participants' perceptions on learning, group membership (with / without agents) had no significant effect on *the amount learnt from the study overall*. Hence, $\mathbf{H_{0,\,3}}$ was not rejected with respect to the participants' perceived amount of learning from the study.

4.4.2.2 Association of Group and Enjoyment of Study

In both groups, all individual participants indicated that they enjoyed the study (question 38 in Appendix L for test group participants and question 26 in Appendix M for control groups). Thus enjoyment of the study was identical in the two groups, and the $\mathbf{H_{0,\,3}}$ null hypothesis could not be rejected with regard to this variable.

4.4.2.3 Association of Group Membership and Willingness to Participate in a Similar Study

In both groups, all individual participants indicated that they would like to participate in a similar study in future (question 42 in Appendix L for test group participants and in Appendix M, question 30 for control groups). Thus, willingness to participate in a similar study was identical in the two groups, and $\mathbf{H_{0,\,3}}$ could not be rejected with regard to this variable.

- **Summary: Satisfaction Levels with the Study**

The results of the satisfaction levels for the study as a whole demonstrated that there was no significant difference between participants who used the agents and those who did not with

regard to the amount learnt from the study overall, their enjoyment of participating in the study, and their willingness to participate in a similar study in future. For these three aspects the group membership (with / without PIAs) was found to have no significant effect on the study satisfaction levels, therefore $\mathbf{H_{0,3}}$ was not rejected.

The study participants' responses to the pre-training questionnaire (Appendix D) showed that they had varying competency levels with regard to using computers (some of them had been exposed to a computer before, whereas others had not), most of them were school leavers, and almost all of them believed that learning about computers could give them opportunities to learn about many other new things. Hence, for all these participants taking part in this study could provide various benefits. For those who were exposed to a computer before, participation in the study provided an opportunity to improve their computer skills. For those who had never used computers before, the study provided an opportunity to learn new skills and receive a certificate of attendance to prove that they had successfully completed a computer literacy course. These considerations could explain why the study participants indicated high satisfaction levels with respect to what they have learnt from the study overall, how much they enjoyed it, as well as their willingness to participate in a similar study in future.

The above discussion of the questionnaire data suggests that these results complement the results obtained from the analysis of effectiveness and efficiency during usability testing discussed earlier in the chapter, which in turn suggests that the convergent parallel mixed-methods design chosen produced positive results.

4.5 Observations

Study participants were observed (observation sheet in Appendix K) while they were performing their user testing tasks. The main purpose of the observation was to watch the test and the control group participants in terms of their behaviour and attitudes while using their respective systems during the user testing. A total of 103 participants were observed, specifically 72 participants in test groups who worked with agents, and 31 in control groups who worked without agents.

The data from observations of participants from both group types are summarised in Table 4.29 below.

Table 4.29: Observations

Category	Aspects	Group	
		With agents (N= 72)	Without agents (N= 31)
User Appearance		%	%
	Calm	94.4	80.6
	Nervous	5.6	19.4
	Confused	5.6	19.4
	Interested	97.2	90.3
	Getting Impatient	90.3	32.3
	Involved	95.8	93.5
	Focused (concentrating)	76.4	83.9
	Motivated	97.2	90.3
Other Behaviour	Fidgeting in the chair	4.2	22.6
	Beating fingers on the table	2.8	29.0
	Leaning towards computer screen	69.4	64.5
	Trembling hands while moving the mouse	4.2	25.8
	Rubbing hands	8.3	51.6
Assistance	Not referring to Help menu	N/A	87.1
	Sometimes not following agent's instructions	70.8	N/A
	Asking a neighbour	6.9	45.2
	Instructor giving a participant information on how to do a particular task (hint)	34.7	51.2
	Instructor doing a task step by step together with a participant (help)	5.6	19.4

In Table 4.29, observations are grouped in three categories, namely user appearance, other behaviours, and assistance. Each of these categories will now be discussed.

User appearance:

High proportions of participants in both groups appeared motivated (97.2% in the test group and 90.3% in the control group), interested (97.2% in the test group and 90.3% in the control group), involved (95.8% in the test group and 93.5% in the control group), calm (94.2% in the test group and 80.6% in the control group), and focused or concentrating (76.4% in the test group and 83.9% in the control group). Furthermore, the majority of test group participants (90.3%) showed signs of impatience, compared to only 32.3% in the control

group. A small number of participants in both groups (5.6% and 19.4% respectively) were confused and nervous.

Other behaviours:

As per Table 4.29, 69.4% of test group participants and 64.5% of control group participants were leaning towards the computer screen, indicating that the participants might not have been totally at ease. This observation led the researcher to follow up during the interviews (an advantage of the mixed-method design chosen). Other behaviour included the rubbing of hands (8.3% and 51.6% respectively), hands trembling while moving the mouse (4.3% in the test group and 25.8% in the control group) and fingers beating on the table (2.8% of test group versus 29.0% of control group participants).

Assistance:

According to Table 4.29, 70.8% of the test group participants occasionally did not refer to an agent when performing a task. This behaviour mainly occurred when the text-based agents were used. It was also noted that 87.1% of control group participants were not using the help menu when they encountered problems. Participants in both groups were observed to sometimes ask for hints when struggling or failing to perform a task (34.7% and 51.6% in the test and control group respectively). Alternatively, 6.9% in the test group and 45.2% in the control group simply asked his/her neighbour. Participants in the test group were observed to look for hints related to information not provided by the agents. The two most common questions asked in this regard were:

How do I choose an agent?

How do I change from one agent to the next?

The following are examples of the most frequently asked questions by the control group participants:

How do I start MS Word?

Where do I find the Help menu?

How do I save a file?

How do I change the font colour?

How do I start the spelling or grammar check?

Besides giving hints to the participants, the researcher observed that a small proportion of participants (5.6% in the test group and 19.4% in the control group) was occasionally unable

to perform a task. Hence, the instructor had to assist them step by step in order to complete the specific task.

Summary: Observations

The researcher's observations revealed that, with regard to user appearance, participants who used PIAs appeared more interested, calm, and motivated than those who did not use PIAs. This observation is consistent with the finding that test group participants performed better in all user tests than control group participants.

Nevertheless, some participants from both groups showed signs of nervousness and confusion. In the test group, some participants appeared impatient and seemed to be leaning towards the computer - more so than those who did not use PIAs. This observation could indicate that participants in both groups faced some challenges while using their respective systems to carry out their user test tasks. This finding confirms data from the post-test questionnaire, where participants in both groups affirmed that they had to concentrate to work on their respective systems (mixed-methods).

Concerning other behaviour, participants who did not use PIAs exhibited more of the following compared to those who used PIAs: rubbing of their hands, trembling hands while moving the mouse, fingers beating on the table, and fidgeting in the chair. Data about assistance proved that participants who did not work with PIAs addressed more questions to their neighbours and also needed more hints and help from the instructor than their counterparts who used PIAs. In terms of effectiveness and efficiency, as discussed earlier, these physical indicators of nervousness and discomfort might have contributed towards the test group's superior results. These findings also confirm the post-test questionnaire results where the test group participants acknowledged that the agents' hints helped them to quickly learn how to perform a particular task and help them to feel more confident about their computer skills (mixed-methods).

4.6 Interviews

The researcher conducted interviews (Appendix P) with participants after the user testing sessions. The main goal of conducting these interviews was to gain more insight on some of the study participants' behaviours that were not clearly understood during the observation. Furthermore, it served to clarify some ambiguities and incomplete answers provided by

participants in the post-test questionnaires. Although the interview questions, as presented on the interview sheet in Appendix P, were quite generic, they were adapted to refer to the specific system that the interviewee used during testing. It should also be noted that not all of the 103 study participants could be interviewed since the majority of the study participants were unemployed and actively looking for work, and consequently, they were always in hurry to leave after the test. Thus, not all of them could spare time to be interviewed. In total, 70 study participants were interviewed (50 of them from the test group and 20 from the control group). The interview data related to both the test and control group participants are discussed in subsections 4.6.1 and 4.6.2 below.

4.6.1 Interviews with Test Group Participants

This section contains the synthesis and analysis of the interviews of the 50 test group participants.

What was your experience with the PIAs that you used during the training?

Most of the participants (96.0%) in this group indicated that they were able to use PIAs and had a positive experience working with PIAs during the training. The remaining 4.0% of participants stated that they had mixed feelings at the beginning, but that they managed to overcome their doubts as the training progressed.

Do you think PIAs have the ability to facilitate training for people who have little knowledge of computers?

Almost all test group participants (98.0%) agreed that PIAs can facilitate training for people who have little knowledge of computers. Furthermore, a significant number of participants (88.0%) was also of the opinion that, although PIAs are helpful, there is still a necessity that one should first be introduced to PIAs before using them.

What are the main problems and challenges that you have experienced while using PIAs?

Participants acknowledged experiencing some problems/challenges using the various PIAs during the training/user testing. The majority of participants (98.0%) identified the following as their main challenges/problems:

- There was variation in terms of the agents' voices, specifically in terms of the male agents. In general, the male voices were not clear, which made it difficult to follow the instructions.
- The text produced by the text agents (i.e. agents 1 and 2) moved across the screen too fast and that made it difficult for them to read the instructions.

- Some agents' files took quite a long time to load. Participants experienced waiting time as feeling impatient.

Based on your experience with PIAs, what did you like about them?

Following a summary of the answers provided by most of the participants (98.0%) with regard to the above-mentioned question:

- Texts written in colour were preferred to texts written only in black.
- The female cartoon human (agent 5) was well dressed (professionally dressed), appeared very attractive, and also had a very nice voice.
- The female agents' voices were very clear.
- The brownish colour of the male cartoon dog (agent 8) was visually attractive and the agent itself was cute.
- PIAs' hints made it easier to remember how to perform a given task.

Based on your experience with PIAs, do you have any recommendations for improvements?

In terms of recommendations/ suggestions for the improvement of PIAs, 94.0% of the test group participants suggested the following:

- Remove the text agents (i.e. the one displaying in plain black colour) and leave only the agents with voices.
- Either improve, or totally remove the male agents' voices.
- Introduce PIAs who could speak SA local languages (i.e. Sotho) so that the less educated users who lack computer experience can also learn about computers.
- Expand the use of PIAs beyond word processing so that people can also use them when learning about other concepts.

4.6.2 Interviews with Control Group Participants

Twenty control group participants were interviewed; the responses to each of the interview questions directed to these participants will now be discussed.

What was your experience with the MS Word environment that you used during the training?

A considerable number of control group participants (85.0%) affirmed that they had a positive experience with the MS Word environment. The remaining (15.0%) acknowledged that at the beginning, it was challenging for them but with time they did adjust.

Do you think the MS Word environment has the ability to facilitate training for people who have little knowledge of computers?

More than half of control group participants (65.0%) acknowledged that the MS Word environment can be a challenging experience at the beginning for people who have little knowledge of computers. Most participants (90.0%) were of the opinion that people who have little knowledge of computers need lots of practice before becoming comfortable with the MS Word environment.

What are the main problems and challenges that you have experienced while using the MS Word environment?

Almost all the control group participants (95.0%) who were interviewed recognised that it was difficult for them to find help when they forgot how to perform a given task. A portion of this group (38.0%) also acknowledged that they were anxious and nervous at the beginning, but that their feelings changed positively as they progressed.

Based on your experience with the MS Word environment, what did you like about it?

Almost all participants (95.0%) generally experienced the MS Word environment as a user friendly environment and not complex to use.

Based on your experience with the MS Word environment, do you have any recommendations for improvements?

The majority of the interviewed control group participants (95.0 %) agreed that it should be made easier to access the help function.

Summary: Interviews

The interviews revealed that participants in both control and test groups had a positive experience with the systems they used during the training. Hence, these interview responses are consistent with participants' responses to the post-test questionnaire (Sections 4.4.1.1 and 4.4.1.2), where they indicated that they were able to use their respective systems (MS Word for control participants and PIAs for test group participants) to perform the various tasks given to them during the user testing. Participants from both groups agreed that their respective systems could be used to facilitate training for people who had little knowledge of computers.

Nevertheless, in both groups, participants were of the opinion that in order to properly use the systems, one must, first of all, be introduced to it. This explained why participants in both

groups in the post-test questionnaire indicated that they had to concentrate in order to use their respective systems to carry out their test tasks. This is also in line with observation results where participants in both groups exhibited, for example, impatience, nervousness, confusion, etc. (refer to Section 4.5) and acknowledged that they did experience problems/challenges while using their respective systems.

These problems/challenges depended on the kind of system that they used during the user test. For example, the following interview responses by the test group participants, namely that there was a variation in terms of the agents' voices, that the text provided by text agents moved too rapidly across the screen and that agent files took too long to load properly, confirm why test group participants in the post-test questionnaire mentioned that they had to concentrate in order to use PIAs to carry out user test tasks. This comment might also explain what was discussed earlier in observations, namely that test group participants were leaning towards the computer screen and appearing to grow impatient.

Control group participants, in their interview responses related to MS Word problems/challenges, indicated that it was difficult to find MS Word help. This finding is in line with their responses in the post-test questionnaire, where they explained that they had to concentrate in order to use MS Word during user test tasks. This also supports what was discussed earlier in observations, namely that (user appearance, other behaviours, and assistance) the control group participants exhibited more negative behaviourisms while using MS Word during the user test than the test group participants (mixed-methods).

Although there were challenges, participants from both groups liked various aspects of their respective systems. For example, control group participants during the interviews stated that the MS Word environment was user friendly. This finding supports control group participants' responses in the post-test questionnaire, namely that the MS Word environment was easy to use and they were able to use it successfully to perform their user test tasks. This further confirms an earlier statement, namely that control group participants managed to perform their user test tasks using MS Word (mixed-methods).

On the other hand, test group participants, as per their interview responses, acknowledged that they preferred some agents to others. For example, interview answers revealed that texts written in colour were preferred to texts written in black, female agents' voices were

preferred to male voices, the brownish colour of the dog was visually attractive, and that PIA hints made it easier for them to remember how to perform a task. These findings complement what test group participants responded in the post-test questionnaire regarding their individual preference of specific agents. Also, it further confirms why there were differences in terms of efficiency and effectiveness with regard to various user test tasks that test group participants performed using PIAs. This is in line with what was discussed earlier in observations, namely that test group participants were sometimes not following agents' instructions, they were leaning towards the computer screen, and were growing impatient (advantage of using mixed-methods).

In terms of recommendations, participants in both groups made different kinds of suggestions, depending on the different challenges they faced while using their respective systems to perform user test tasks. For example, test group participants suggested either improving or totally removing the male agents' voices, while the control group participants requested that the help function access should be easier. The latter also suggested easier access to the MS Word help menu.

In summary, when comparing the participants from both groups, it can be noted that test group participants who used PIAs had advantages compared to control group participants, mainly due to the fact that agents were able to give assistance to the test group participants.

4.7 Summary

This chapter discussed in detail the results of the quantitative and qualitative data analysis, utilising data gathered from four sources, namely user testing, questionnaires, observations, and interviews.

The results of the user testing revealed that, with regard to efficiency and effectiveness, the test group participants outperformed the control group participants. Moreover, a difference in terms of efficiency and effectiveness was also found within test group participants with regard to various user test tasks that they performed with the different kinds of agents.

As per their answers to the questionnaires, test and control participants confirmed that they were able to use their respective systems and also experienced some problems (concentration, frustration and nervousness) while using them.

The results of the observation revealed that some participants, in both groups, displayed physical indicators of nervousness and discomfort during user testing, however, more severe physical indicators of nervousness and discomfort were noted for participants in the control group than for those in the test group.

Interview results suggested that participants in both groups had positive experiences and challenging experiences while using their respective systems (i.e. the text provided by text agents moved too rapidly across the screen, agent files took too long to load properly, difficulty to locate MS Word help, etc.).

Chapter 5: Conclusion

5.1 Introduction

The aim of this research study was to establish, through user testing, whether the incorporation of PIAs in adult computer literacy training could improve and ease the training of adult computer illiterates in SA (Chapter 1). In order to achieve this aim, performance measurement was employed as the user testing technique in the context of this study (subsection 3.4.4.7). A total of 103 participants were recruited. These 103 study participants were divided into two groups, namely a test group and a control group. The test group consisted of 72 participants who were trained using SMOS incorporating 10 PIAs, while the control group consisted of 31 participants who were trained using MS Word (i.e. without agents). Both groups were given 11 basic word processing tasks to complete on their respective systems (i.e. SMOS or MS Word) during a user test. The user testing served to capture usability metrics such as *effectiveness* (number of errors), *efficiency* (task effort) and *satisfaction* (subjective opinions about the systems) in order to compare the performance of these two groups of participants (Chapter 3). The usability metrics captured while participants performed tasks on their respective systems, as well as the subjective results obtained from the post-test questionnaire, were analysed and discussed in Chapter 4.

The current chapter will use the results of the analysis (Chapter 4) in order to answer the main and secondary research questions (Section 1.3) and hypotheses (Section 1.5) posed in the Introduction (Chapter1). The other sections that will be discussed in this Chapter (see Chapter Map in Figure 5.1) include the motivation, findings, limitations, possible future research, and lastly, the contributions of this research study.

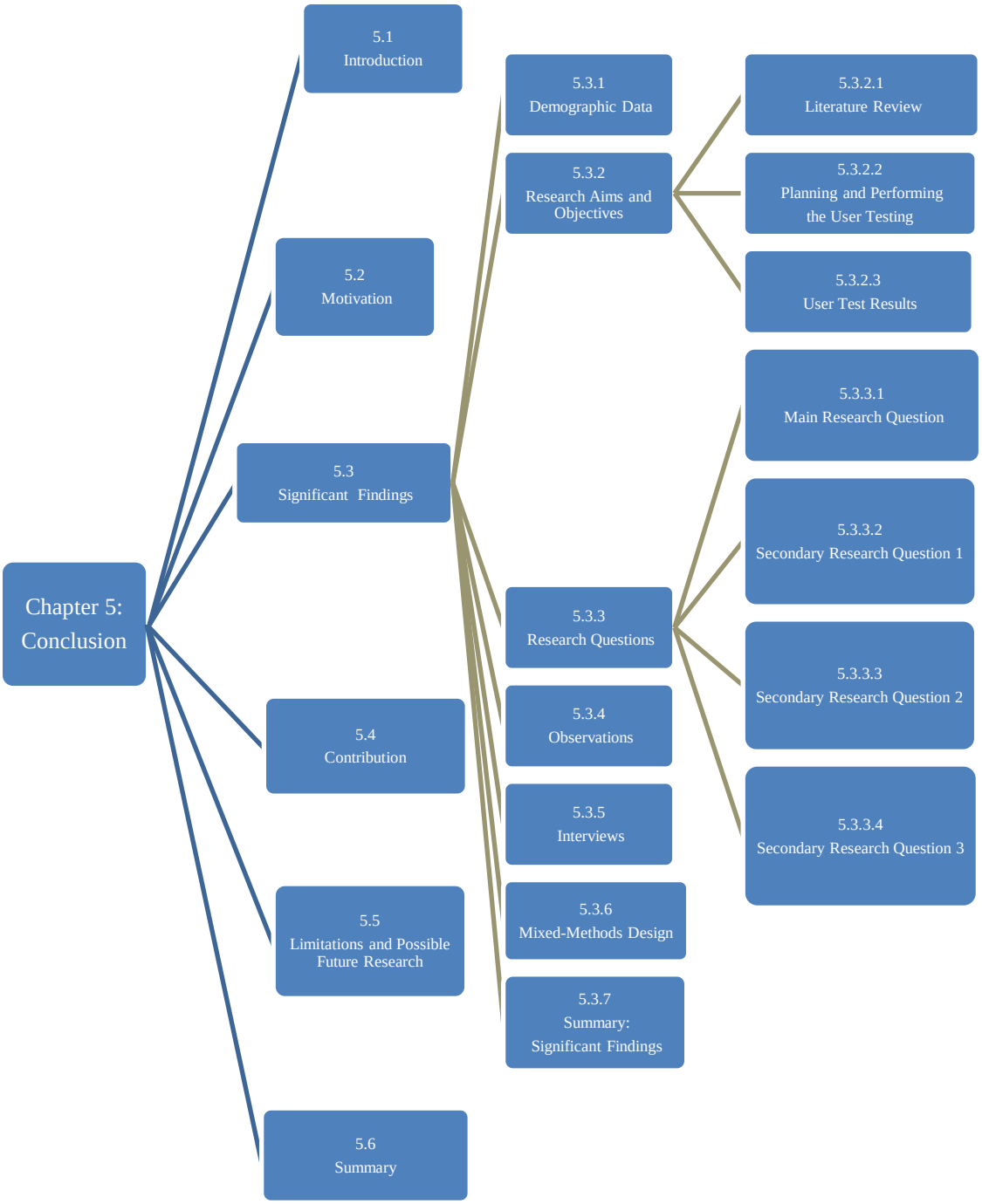


Figure 5.1: Schematic Representation of Chapter 5

5.2 Motivation

In the digital age society is becoming more technological-oriented. In line with this phenomena, the World Literacy Foundation (2015) pointed out that in modern society literacy is no longer considered as synonymous for being able to read and write only, but also involves the acquisition of the skills necessary (i.e. computer literacy skills) for effective and productive performance within a society. For example, possession of computer literacy skills is one of the major requirements to enter the job market. It is, therefore, important for individuals to be computer literate. Yet, the challenge in a developing 3rd world country (i.e. SA) is that technological illiteracy and lack of formal education prevent large parts of the adult population from effectively participating in social and economic activities, as well as to become part of the workforce. In order to prevent these individuals from further marginalisation in society, there is a need to give them the necessary learning opportunities, such as basic computer training, which can promote their skills development for employability. Up to now, computer training has generally been conducted using approaches such as conventional training (training conducted by a skilled human instructor) and e-learning (using the Internet to conduct training), which might also be challenging for those less familiar with technology, or less educated. Hence, it is critical to find innovative approaches to ease technology transfer to adults with little or no technological background or formal post-school education in 3rd world countries.

Bearing this set of challenges in mind, the current study was an attempt to find ways to facilitate and improve the computer literacy training experience for those less familiar with technology or less educated, specifically adult learners in SA. In an effort to achieve this objective, SMOS, a simulated word processor system developed by Potgieter (2010) incorporating 10 PIAs (varying in terms of appearance, gender, voice and reality) was used to train and assess a sample of these adult learners. Hence, this study aimed to assess, by means of usability evaluation (user testing), the extent to which each of these 10 PIAs could facilitate the computer training for these adult learners without compromising the training quality.

5.3 Significant Findings

This section presents conclusions based on the findings as discussed in Chapter 4. The findings will be discussed in terms of demographic data, research objectives and aims,

research questions (main and sub-questions), observations, as well as interviews. The discussion will be based on the research problem for this study as explained in Section 1.2. It is also important to note that in this study reliability and validity aspects have been addressed by means of using multiple sources of data directly linked to the current research aims and objectives. This was further achieved by clearly specifying all aims, objectives, justifications of the adopted research paradigm and methods, decisions and procedures.

5.3.1 Demographic Data

Before the training commenced, all study participants completed a pre-training questionnaire (Chapter 3) for the purpose of assessing whether they adhered to the profile of the targeted population. The results of the pre-training data analysis (Chapter 4) revealed that:

- Most of the participants had a matric certificate as highest qualification.
- Study participants had the ability to speak and write English.
- They had different levels of prior practical exposure to computers (some had exposure, others not).
- Most of the participants were between the ages of 20 and 30.

Hence, it can be deduced that the profile of study participants was demographically similar to the adult learner population targeted for the purpose of this study.

5.3.2 Research Aims and Objectives

The aim of this research, as specified in Section 1.4, was to establish, through user testing, whether the incorporation of a variety of PIAs could improve and facilitate the computer literacy training for adult computer illiterates in SA. This was achieved in this study by dividing the research aim into three objectives. The first was carrying out a literature review, the second was the planning and performing of user testing, and the third was applying the user testing results to practical adult computer literacy training in 3rd world countries. Findings on each of these objectives will now be summarised.

5.3.2.1 Literature Review

Section 1.1 highlighted that the scope of this study consisted of three main areas, namely agents, adult computer literacy training and usability. An extensive literature review was done in order to better understand each of these three main areas (Chapter 2). With regard to

agents, the literature review covered different types of agents, interface agents' application domains focusing on educational agents, examples of existing PIAs systems, and existing studies on PIAs. The current study investigated the potential of PIAs to facilitate adult computer literacy training. To date several studies have shown that agents have the ability to improve students' learning engagement and motivation. Yet, little is known about the use of PIAs in word processing environments, and specifically in the context of adult computer literacy training. Concerning adult computer literacy training, the focus of the literature was on adult computer literacy training in SA. In SA to date, adult computer literacy training has generally been conducted using the following approaches, namely conventional training (conducted by skilled human instructors) and e-learning (using the Internet to conduct training), which posed intellectual challenges to people who are technologically challenged. In the literature review related to usability, the emphasis was on usability evaluation and usability evaluation methods. In this study, user testing (specifically performance measurement) was used. Additional data collection tools such as questionnaires, observations and interviews were used to supplement metrics collected by means of performance measurement.

5.3.2.2 Planning and Performing the User Testing

Dix *et al*. (2004), Nielsen (1993) and Rubin (1994) identified the test objectives, the target user profile, method of the test, task list, test environment, schedule, equipment requirements, evaluator role, kind of data to be collected and analysis process as the issues that need to be addressed during the user test plan. In this study all these issues were addressed in Chapter 2.

User testing consists of asking the end-users to individually complete one or a set of tasks using the system or a prototype system in a controlled environment (Nektarios *et al*., 2010; Partala and Kangaskorte, 2009; Zhang and Basili, 1996). The user testing conducted in this study aimed to measure the usability attributes (effectiveness, efficiency and satisfaction) of incorporating PIAs on adult computer literacy training (Chapter 1). In order to achieve that, a review of all the matters related to performing the user test, such as techniques for user testing, user testing metrics, the user testing plan, sampling, recruitment of test participants, preparation of the test material and the ethics processes involved were covered in Chapter 2.

5.3.2.3 User Test Results

In this study, the user test results served two purposes:

- To identify the changes in knowledge, attitude and aspiration of computer literacy training participants based on their computer literacy training with PIAs, and
- To suggest ways to incorporate PIAs in future computer literacy training for adults.

These two purposes will now be addressed individually.

Identify the changes in knowledge, attitude and aspiration of computer literacy training participants based on their computer literacy training with PIAs

Based on the satisfaction results of the incorporation of PIAs in SMOS, the changes in participants' knowledge, attitude and aspirations regarding their computer literacy training with PIAs became evident as participants strongly agreed / agreed that:

- They were able to use agents successfully.
- They trusted the advice from the agents.
- The agents' hints helped them to feel more confident about their computer skills.
- They could encourage friends to use agents when learning new concepts.
- It was exciting working with the agents.
- Working with agents made them change their attitude towards computers.
- Their experience with agents encouraged them to find out more about them.
- They would consider using agents when learning real-life concepts.

Therefore, it can be deduced that the use of PIAs positively influenced the changes in participants' knowledge, attitude and aspiration.

Suggesting ways to incorporate PIAs in future computer literacy training for adults

Referring to the study results related to PIAs, it was noted that PIAs in general have the capability to support adult computer literate learners in performing their word processing tasks. For example, user testing results in this study confirmed that those who used PIAs outperformed those who did not, especially where effectiveness and efficiency were concerned. At the same time it was noted that those who used PIAs did not relate well to all the PIAs. This can be due to different factors, for example external characteristics of PIAs (appearance, voice and movement) that might not have been enjoyable to the same degree for participants. Another possible factor might be the characteristics of adult learners (refer to Section 2.6 for the six principles of adult learners in Chapter 2). Hence, in order to incorporate PIAs in future computer literacy training efforts for adults, it is suggested that

attention be given to participants' preferences regarding external characteristics of PIAs (appearance, voice and movement), and that the characteristics of adult learners (Chapter 2) also need to be understood. This supports the claim by Strafling *et al*. (2010) that the inclusion of PIAs can be beneficial to adult learners, provided that appropriate criteria of the agents are applied.

5.3.3 Research Questions

The results of the analysis (Chapter 4) will be used in order to answer each of the main and secondary research questions in the subsections to follow.

5.3.3.1 Main Research Question

What is the level of usability of PIAs used in adult computer literacy training?

In answering the main research question of the study, user testing was conducted for the purpose of testing the usability of the 10 PIAs incorporated in SMOS (Chapter 3). As described in Section 3.4.4.2 study participants were divided into two groups, namely the test group (trained with SMOS) and the control group (trained with MS Word, without agents). During the user testing, participants from both groups were given 11 basic word processing tasks to complete using their respective systems (i.e. SMOS or MS Word). The user testing sought to capture two types of data related to usability attributes of the systems, namely performance data (efficiency and effectiveness) and preference data (satisfaction) (Chapter 3). This data was used to compare the two word processing systems (SMOS or MS Word) used by participants in the user test. This comparison aimed to assess the usability of each of the 10 PIAs incorporated in SMOS (Chapter 3). In general, the comparative performance data showed that test group participants (using PIAs) outperformed the control group participants (no PIAs) in both efficiency and effectiveness (Chapter 4). With regard to the satisfaction, however, it was noted that there was no difference between participants from the two groups.

These findings are an indication that the use of PIAs has the ability of overcoming many problems such as computer skills uncertainty, lack of self-esteem and confidence faced by adult computer illiterates during the training, and also enriches their computer training experiences. Hence, applying these findings to the main research question posed in this study, it can be said that PIAs had a positive usability effect on adult computer literacy training. Furthermore, these findings are in line with the claim by Schroeder and Adesope (2013), and Wonisch and Cooper (2002) that the educational multimedia and computer-based training industries should look towards PIAs as a promising solution to the challenges of modern

educational environments. The findings also support the claims made by Atan *et al*. (2008), Bowman (2012), Mao and Li (2010), and Morozov *et al*. (2004) that PIAs have the ability to provide individualised instruction, which is tailored based on the learners' learning abilities, rate of learning and needs.

In the next subsections an attempt to answer each of the three secondary research questions will be made.

5.3.3.2 Secondary Research Question 1

How effective is it for adult learners to perform their computer training tasks with the assistance of PIAs?

In order to answer this first secondary research question, it was hypothesised that:
There is no difference in the usability performances in terms of effectiveness (number of errors) when using PIAs in adult computer literacy training compared to using conventional computer training techniques ($\boldsymbol{H_{0,1}}$*).*

In order to test this hypothesis, a user test was conducted by means of task assessments whereby participants in both groups (i.e. test and control) were given 11 word processing tasks to complete (Chapter 3). The two groups (i.e. test and control) were compared in terms of the number of errors per each task, and in terms of the total number of errors. The statistical analysis revealed a significant difference between the assessment groups' effectiveness when using the assistance of PIAs to complete tasks. Also, the results from the two-way model for this data showed that there was a statistically significant effect for assessment group (i.e. with and without agents), as well as for previous experience with computers.

Hence, with regard to effectiveness, it can be said that the use of the PIAs has the potential to reduce the number of errors (i.e. number of errors in total and per individual task) - the assistance of PIAs did effectively influence adult learners when performing their computer literacy training tasks. This result supports Dincer and Doganay (2015), Hong *et al*. (2013), and Gulz' (2004) findings that PIAs were able to enhance comfort in a learning environment, motivate learning behaviour, and fulfil personal relationships to learning.

5.3.3.3 Secondary Research Question 2

How efficiently can adult learners complete their computer training tasks with the assistance provided by PIAs?

According to the 2nd hypothesis **($H_{0,2}$):**

There is no difference in the usability performances in terms of efficiency (task effort) when using PIAs in adult computer literacy training compared to using conventional computer training techniques.

This hypothesis was formulated in order to answer the second secondary research question. Here, efficiency, namely task effort, was measured. The statistical comparison of the two groups revealed that higher proportions of participants who used the assistance provided by PIAs achieved their tasks than those who did not use PIAs. The statistical result also indicated that there was a variation in terms of scores within the group of participants who used PIAs' assistance. It was mentioned in Chapter 3 that test group participants used 10 different kinds of PIAs (in terms of appearance, voice and movement) while performing their word processor tasks. Therefore, the variation in scores within the test group participants could be an indication that participants in this group did not relate well to all of the SMOS incorporated PIAs. The efficiency finding with regard to test group participants was in line with the claim made by Carmody and Berge (2005) that emotions can be a barrier to true learning for adults, who bring a wealth of experience to the instructional environment. This also supports the claim by Shneiderman and Plaisant (2010) that PIAs have the ability to increase anxiety and decrease performance in adults.

Using the efficiency (task effort) comparative results to answer the second secondary research question, it can be said that adult learners who made use of PIAs completed their training tasks with different levels of efficiency while using the assistance provided by PIAs. The analysis results also revealed that there was no association between participants' level of education and efficiency. Likewise, participants' age group had no significant effect on their efficiency. This further revealed that neither education level nor age group is a requirement (or barrier) for using PIAs. This is an interesting finding which implies that PIAs have the

ability to support adult learners with different levels of education or from different age groups.

5.3.3.4 Secondary Research Question 3

How do adult learners feel about their ability to accomplish their computer training goals using PIAs?

Participants of both the control group (using MS Word) and the test group (using SMOS) completed a post-test questionnaire after performing the user test to indicate their satisfaction levels with these respective systems.

With regard to the satisfaction levels in terms of the systems, the data analysis from the control group participants revealed that the majority (87% and more) of participants were satisfied with the MS Word environment.

For the test group participants, there were differences between participants in terms of three aspects that were examined, namely (i) the study group participants' preference regarding individual PIA, (ii) their enjoyment levels with PIAs, and (iii) their attitudes toward PIAs in general.

- **Test group participants' preference regarding individual PIAs**

The findings on the test group participants' preference regarding individual PIAs that they interacted with revealed that:

- They preferred a cartoon agent to a realistic agent.
- They preferred a male agent to a female agent.
- They preferred a text agent to a combined text and audio agent.
- A dog agent was preferred to a human agent.

Therefore, it can be concluded that test participants varied with regard to their preferences for individual PIAs that they interacted with.

- **Test group participants' enjoyment levels with PIAs**

The results below are listed from the most enjoyed PIA to the least enjoyed one as rated by test group participants:

- Male realistic dog
- Both the male cartoon dog and the female combined text & audio agent

- Both the female cartoon dog and the male cartoon human agent
- The male combined text & audio agent and the female cartoon human agent
- Female realistic dog agent
- Female text agent
- Male text agent.

Hence, based on the results above, it can be said that test group participants had different levels of enjoyment with regard to the 10 PIAs that they used.

Test group participants' attitudes towards PIAs

In this study, the attitudes towards PIAs incorporated in SMOS were evaluated on three aspects, namely appearance, voice and movement. These results revealed that:

- In terms of appearance, they were more positive towards female text and male cartoon dog agents;
- In terms of voice, they were more positive towards the female combined text & audio, and the male cartoon dog agents; and
- In terms of movement, they were more positive towards the female cartoon human and male cartoon dog agents.

Summary: Overall Satisfaction Levels in terms of PIAs

The satisfaction results across all three criteria (appearance, voice and movement) by test group participants indicated that the male cartoon dog agent was the most preferred agent, followed by the female text agent, and the female text & audio agent. The female realistic dog was the least popular.

Referring to the results discussed above, it can be deduced that test group participants' satisfaction levels in terms of PIAs were influenced by their subjective preference of the external characteristics (appearance, voice and movement) of that particular PIA. For example, the male cartoon dog was selected as the most liked in appearance, voice and movement. As a result, the male cartoon dog also was chosen among the top PIAs that participants found to be enjoyable and preferable. Hence, using these results to answer the third secondary research question, it can be said that there was a difference in the satisfaction levels of test participants in terms of their ability to accomplish their computer training goals using PIAs. This is line with the claims made by others researchers such as Haake and Gultz

(2008), Theodoidou (2011), and Veletsianos (2010), namely that the agent's given observable characteristics has an impact on the manner in which some learners relate to that particular agent.

However, the statistical comparison of enjoyment revealed no significant difference in study satisfaction levels between participants from the control and the test groups in terms of:

- amount learnt from the study,
- enjoyment of being part of the study, and
- willingness to participate in a similar study in future.

5.3.4 Observations

As already shown in Table 4.29, observation results were grouped in three categories, namely user appearance, other behaviour, and assistance. A brief comparative summary of test and control group participants with regard to each of these three categories will now be provided.

User appearance

The test group participants appeared more interested, calm, and motivated than those in the control group, a possible indication that they enjoyed or might even have been intrigued by the agents that they used.

Despite the fact that participants from both groups displayed signs of nervousness, discomfort and confusion, these physical indicators were more obvious among participants in the test group that did make use of agents.

In the test group, some participants appeared impatient and seemed to be leaning towards the computer more than those who did not use PIAs. This could be explained by responses given via questionnaires and interviews, where test group participants indicated that they experienced problems with slow loading times for agents, or that they needed to lean forward to hear what the agents were saying at the time.

Other behaviour

Rubbing of hands, trembling hands while moving the mouse, beating fingers on the table, and fidgeting in the chair were behaviours that were observed more commonly in the group of participants who did not use PIAs, possibly indicating their difficulty to get tasks done without easy obtainable assistance.

Assistance

The group of participants who did not work with PIAs addressed more questions to their neighbours, and also requested more hints and help from the instructor than their counterparts who used PIAs. This seems to be a feather in the cap of the PIAs as it might be an indication that the assistance provided by the agents enabled the participants to help themselves.

5.3.5 Interviews

The researcher conducted interviews with selected participants after the user testing sessions. The results of the test and control groups' comparative interview data revealed the following:

- Participants in both control and test groups had a positive experience with the systems they used during the training.
- Participants from both groups agreed that their respective systems could be used to facilitate training for people with little knowledge of computers. Additionally, participants from both groups were of the opinion that in order to properly use the systems, one must first be introduced to it quite thoroughly.
- The problems/challenges that participants experienced included difficulty to find the MS Word help functions (control group participants), while test group participants had to deal with different preference levels with regard to the various agents that they used. Despite the challenges, participants from both groups also liked some other aspects of their respective systems.
- Participants from both groups made suggestions concerning improvements to their respective systems. For example, test group participants suggested to either improve or totally remove the male agents' voices, while the control group participants requested that it should be easier to access the help function.

5.3.6 Mixed-Methods Design

As mentioned in Chapter 3, mixed-methods research is a research approach whereby the researcher uses a combination of qualitative and quantitative methods in a single research study to appropriately address the research questions or to obtain rich insights into the phenomena under investigation (Creswell, 2009; Creswell and Plano Clark, 2011; Greene, 2007; Hallebone and Priest, 2009). Its main benefit is to merge the strengths and improve the weaknesses of both qualitative and quantitative methods (Creswell, 2009; Creswell and Plano Clark, 2011; Greene, 2007; Hallebone and Priest, 2009).

A convergent parallel mixed-methods design was chosen for use in this study. In this context, a convergent parallel mixed-methods design was applied through the collection of data using multiple methods, including user testing, questionnaires, observation and interviews. These different data collection methods produced various kinds of results.

In confirmatory research, the researcher seeks to establish whether research predictions or research hypotheses have been confirmed by data (Robson, 2011: 419). The different results obtained by means of the four data collection methods used in this study supported, confirmed, and reinforced one another. Hence, a combination of these results was used in order to confirm or reject each of the three formulated hypotheses (Chapter 4), as well as to answer the research questions (one main question and three sub questions) and strengthen the research findings and conclusions (Chapter 5).

According to Johnson and Christensen (2012: 439), complementary methods involve the researcher seeking elaboration, enhancement, illustration, and clarification of the results from one method with the results from another method. In the context of this study, the results produced by each of these data collection methods complemented each other in some instances, adding value to the validation of the research findings.

The results of the user testing revealed that, with regard to effectiveness and efficiency, the test group participants, who used agents' assistance, outperformed the control group participants, who worked without agents. Although the questionnaire and interview results indicated that both the test and control group participants found their respective systems easy to use and that their experiences were positive, the results from observation revealed that control group participants showed more physical indicators of nervousness and discomfort than their counterparts in the test group, thereby complementing the user test findings.

Within the test group participants, the user testing results also showed that there were differences in the performance (efficiency and effectiveness) with regard to certain user test tasks where the various agents were used. These findings were confirmed by the test group participants' responses to the questionnaire where they indicated certain preferences towards individual agents. The interview responses acknowledged these preferences, thereby complementing the findings of the user testing and questionnaires.

Participants in both groups (test and control) confirmed, in their questionnaire responses, that despite the fact that they were able to use their respective systems, they did experience problems while using their systems (i.e. the text provided by text agents moved too rapidly

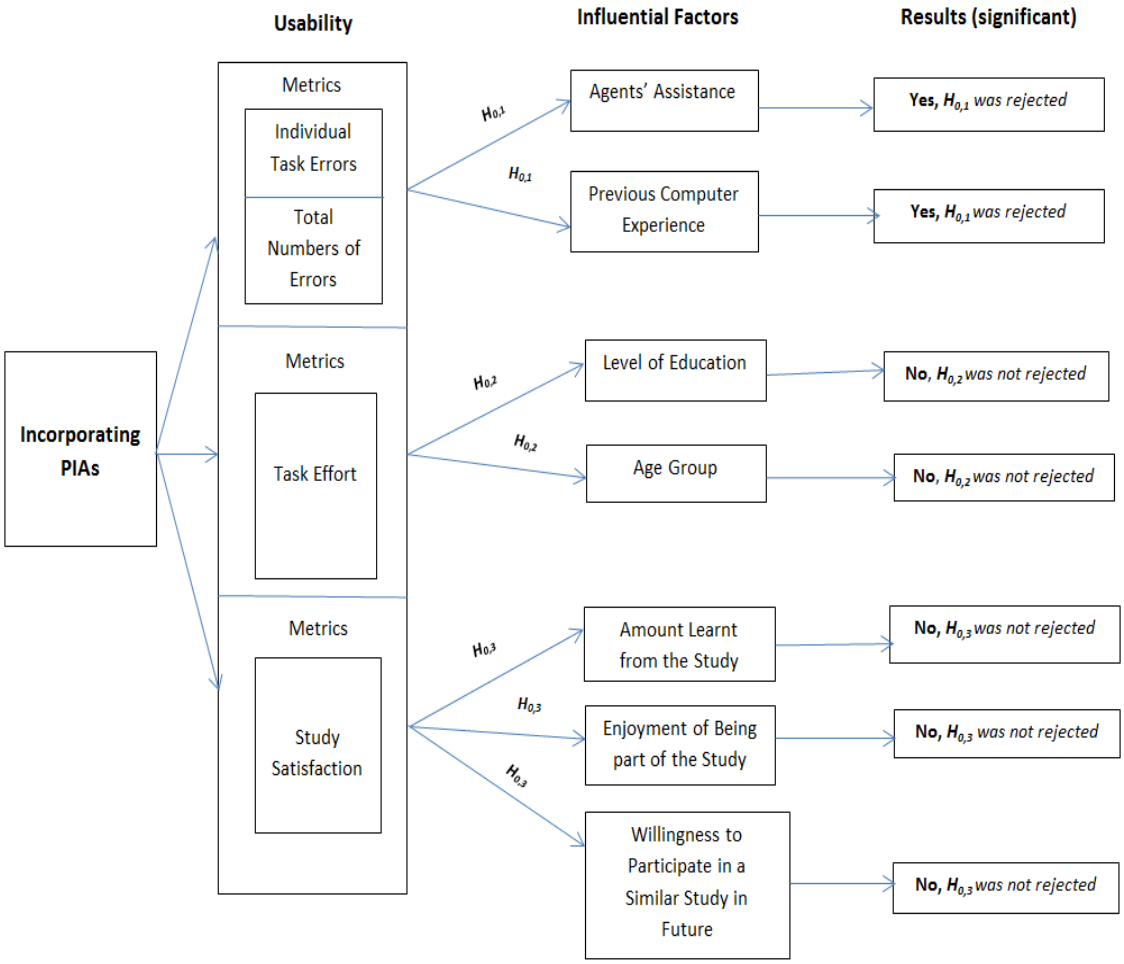
across the screen, agent files took too long to load, difficulties in using MS Word help, etc.) . During observation, participants in both groups showed signs of nervousness and confusion, a fact that was confirmed during interviews (i.e. difficulty in finding MS Word help, confusion as a result of variation in terms of agents' voices, severe concentration in order to be able to carry out user test tasks, etc.). Here, the mixed methods used were again complementary in terms of results.

During observation, certain physical indicators of nervousness and discomfort were more evidently displayed by control group participants. This could be explained by questionnaire responses where some of the test group participants acknowledged that the hints provided by the agents helped them to quickly learn how to perform a particular task and, therefore, boosted their confidence about their computer skills. On the contrary, a few of the control group participants confirmed their nervousness and discomfort during interviews, putting the blame on the difficulty in finding appropriate MS Word help functions.

The discussion above illustrates how the convergent parallel mixed-methods design in this study produced a richness of data where results produced by one method could be confirmed or explained with the use of another.

5.3.7 Summary: Significant Findings

Between-subject and within-subject testing methods were used during user testing (see Section 3.4.4.3). Between-subject testing was used to compare performance (effectiveness, efficiency) and satisfaction levels ($H_{0,1}$, $H_{0,2}$ and $H_{0,3}$) between test group (used PIAs) and control group (did not use PIAs) participants. The between-subject comparison sought to assess how well the incorporation of PIAs could assist adult learners in acquiring basic computer skills. The summary of the results of incorporating PIAs (between-subject) in terms of effectiveness (number of errors for each individual task, and total number of error), efficiency (task effort), and study satisfaction (amount learnt from the study, enjoyment of being part of the study, and willingness to participate in a similar study in future), is shown in Figure 5.2.



Notes: $H_{0,1}$, $H_{0,2}$, and $H_{0,3}$ represent the three formulated hypotheses (see Chapter1)

Figure 5.2: Diagrammatic Results of Incorporating PIAs (between-subject)

Figure 5.2 shows that assistance provided by PIAs and computer experience were positively associated with the drop of both number of errors for each individual task, and total number of errors. In other words, the incorporation of PIAs and computer experience significantly predicted effectiveness. This finding indicates that PIAs provided better support to the group of participants who used them, which could explain the improved performance for this group in terms of effectiveness.

With regard to efficiency, the task effort results as shown in Figure 5.2 reveal that neither participants' level of education nor their age was significantly associated with efficiency (task effort). This finding implies that the adult participants' level of education and their age did not influence their performance when working with PIAs.

With regard to the study satisfaction, the results as displayed in Figure 5.2 show that, based on the participants' subjective perceptions, amount learnt from the study, enjoyment of being part of the study, and willingness to participate in a similar study in future, were similar or even identical in the cases of amount learnt, enjoyment and willingness to participate in a similar study for the two study groups (test group using PIAs and control group, not using PIAs).

5.4 Contribution

This research study investigated whether the incorporation of PIAs could ease and improve computer literacy training for adult computer illiterates in SA. The findings of this study have contributed to the field of PIAs in several ways.

Literature revealed that PIAs are being used in computer instructional fields (Chapter 2). Prior to this study, very little was known about the use of PIAs in adult computer literacy training, especially in terms of word processor training. According to Carmody and Berge (2005), most of the previous studies on PIAs focused on childhood to undergraduate, college-aged adult populations. In terms of population, therefore, the novelty of this study lies in its focus on adult computer illiterates of varying ages with no formal post-school training (with some of these learners not being exposed to learning materials for many years) in the context of a 3rd world country, in this case specifically SA.

In general, the findings of this research study indicated that PIAs have the potential to improve adult computer literacy training in SA. For example, it was noted that in terms of both effectiveness and efficiency, participants who worked with PIAs outperformed those who did not use them when performing the same successive user testing tasks.

Drawing on the findings of this research study, PIAs seem to be able to offer a number of benefits that can improve adult computer literacy training in SA. However, it is suggested that key aspects, such as external observable characteristics of PIAs, characteristics of adult learners, and adult learners' ability/satisfaction with the system (shown in Figure 5.3), need to be systematically explored.

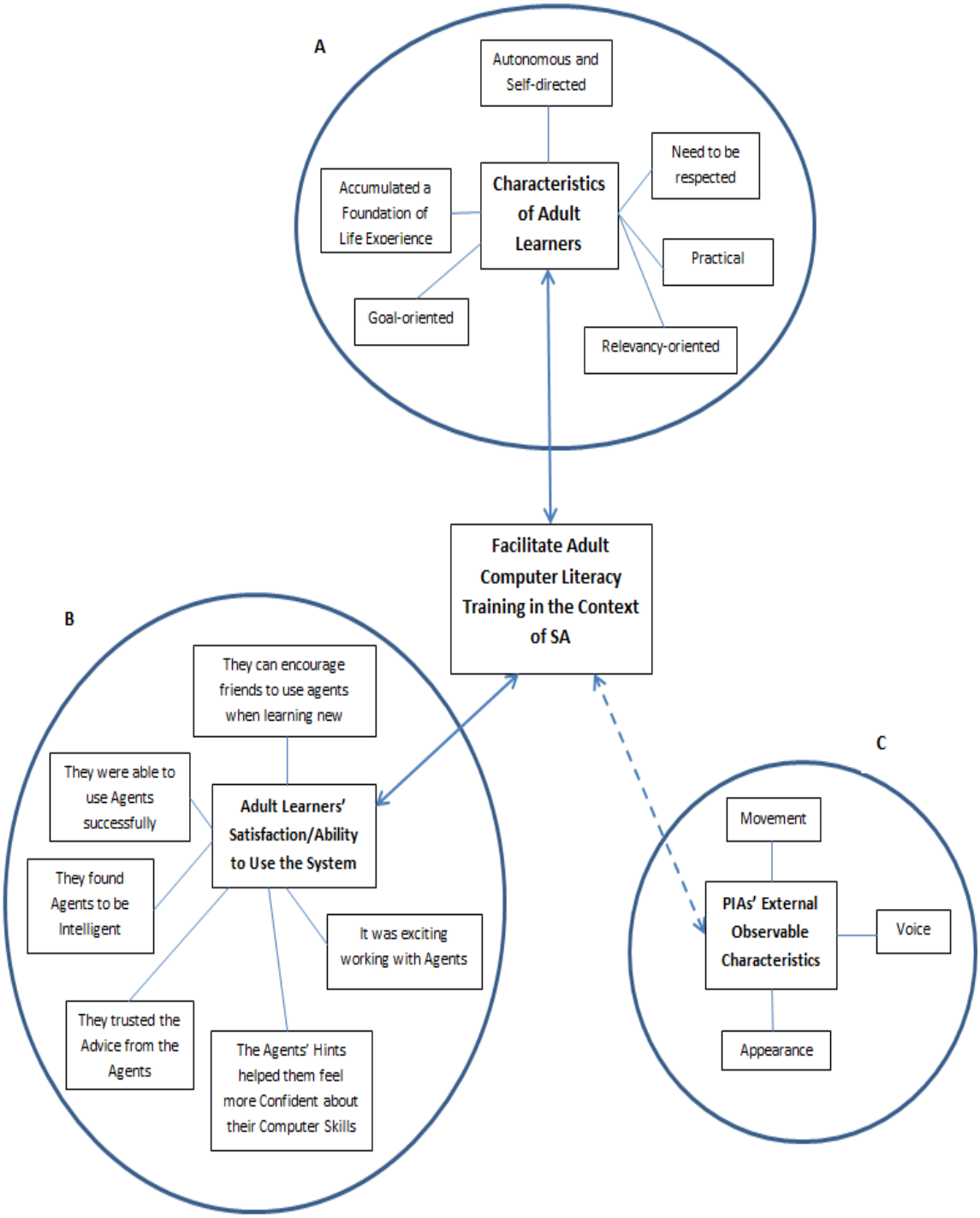


Figure 5.3: Improving Adult Computer Literacy Training

Figure 5.3 provides guidelines with regard to key aspects to improve adult computer literacy training in SA. As shown in Figure 5.3 each one of these key aspects (characteristics of adult learners (A), adult learners' satisfaction/ability to use the system (B), and external observable

characteristics of PIAs (C)), is linked to different factors by which it is defined. Each of these aspects will now briefly be explained.

- **Characteristics of Adult Learners**

In this study it was noted that many factors define the characteristics of adult learners (see Figure 5.3 (A)). These characteristics include being autonomous and self-directed, need to be respected, practical, goal-oriented, relevance-oriented, and accumulated foundation of life experience. Therefore, to successfully integrate PIAs into adult computer literacy training, these factors that define adult learners need to be well understood.

- **Adult Learners' Satisfaction/Ability to Use the System**

A system should be user-centred. This study indicated that PIAs incorporated in SMOS could assist people of different age groups and educational levels. In general, irrespective of their age or educational level, test group participants were able to perform word processing tasks using PIAs. Their ability to use PIAs led to high satisfaction levels in terms of PIAs. Some factors that potentially could influence adult learners' high system satisfaction levels include the fact that few test group participants (15.7%) felt frustrated working with agents. Additionally, only 23.2% of participants in this group felt nervous when working with agents (see Table 4.21). In general, the vast majority (90% and more) of participants who used PIAs felt that they were satisfied with respect to the following: they were able to use agents successfully, they trusted the advice from the agents, the agents' hints helped them feel more confident about their computer skills, they could encourage friends to use agents when learning new concepts, they found agents to be intelligent, and it was exciting working with agents, as shown in Figure 5.3 (B). These factors created high satisfaction levels regarding PIAs. This finding suggests that the use of PIAs could be advantageous, especially in the context of the adult computer literacy training in 3rd world countries, where technological illiteracy is highly prevalent. With the help of PIAs adult computer literacy trainees could develop positive attitudes about their ability to use technology. It is suggested that, to successfully integrate PIAs in adult computer literacy training, these aspects need to be taken into account.

- **PIAs' External Observable Characteristics**

The findings from this research study indicate that PIAs' external observable characteristics could play a role in how adult learners related to a particular PIA. PIAs' external observable characteristics in this study comprised several factors, such as movement, voice and

appearance (see Figure 5.3 (C)). Adult computer literacy trainees created subjective impressions about PIAs based on those external observable characteristics. These impressions can, to some extent, differ from one individual to another. However, the findings of the study revealed that there were only small differences in the manner in which test group participants preferred individual agents (see Table 4.22). Also, data in Table 4.23 suggested that test group participants' enjoyment levels were high with regard to the various PIAs they used. Hence, PIAs' appearance, voice and movement were not that important, because at least 73% of participants in the test group were satisfied with all PIAs, with only a slight preference pressed to make a choice. It is suggested that, to successfully use PIAs as a tool for facilitating adult computer literacy, only relatively little consideration needs to be given to the various factors that define external observable characteristics attached to a particular PIA.

This study has shed some light on and laid a foundation for the understanding of how to incorporate PIAs in adult computer literacy training, particular in a word processing environment. The findings presented in this research study suggested that PIAs are suitable tools for facilitating adult computer literacy training in 3rd world countries, specifically in SA. At the same time, it is also suggested that special attention be given to the important issues related to the incorporation of PIAs identified in this study, namely adult learners' preferences regarding external characteristics of PIAs, the characteristics of adult learners, as well as adult learners' ability to use the system. Hence, the findings of this study and the lessons learnt during the course of this study could serve as a foundation on which to base further projects where PIAs are used to improve computer literacy training for adult computer illiterates in SA, or even other 3rd world countries.

In this light, the following practical guidelines are presented for the use of PIAs in the computer literacy training of adult computer illiterate users, specifically in a 3rd world context. These guidelines are based on the practical experience gained by the researcher through observation, as well as through feedback from the participants from the questionnaires and interviews utilised during this study. Table 5.1 provides a summary of practical guidelines for the use of PIAs in adult computer literacy training.

Table 5.1: Practical Guidelines for the use of PIAs in Adult Computer Literacy Training

Category	Sub-category	Guidelines
Physical venue	• Location	• How far
	• Conditions	• Lighting • Temperature
	• Equipment	• Computers – how many • Minimum requirements for visuals and sound • Earphones
	• Layout	• Circle / rows • How close together
	• Disturbance and Comfort	• No distractions • Relaxed atmosphere
Training	• Pre-training assessment	• Use a pre-training questionnaire to assess participants' technological level • See each one as individual
	• Assistance	• Do not interfere too much or too often, but be available • Minimise contact with participants while working • Be available at all times
	• Training materials	• Participants' technological level should determine the level of the training materials • Flexibility in terms of experience levels should be built into the training material
	• Training tasks	• Training tasks should be broken down into individual tasks to ensure that the agent's help can be specific and do not require high memory loads
	• Training schedule	• Training sessions should not exceed 30 minutes at a time • Emphasis should be on practical involvement and not on theory

Agents	• Helpfulness	• Ability of agents to assist participants to perform a task
	• Agent features	• Cartoon vs. Realistic • Human vs. Animal • Male vs. Female
	• Interaction /Communication style	• Text • Text and voice • Physical agent and voice • Voice clarity
	• Visual appearance	• Professional • Casual • Colour
	• Movement	• Gesture (agent's eyes and mouth move while speaking) • Text being displayed on the screen

The guidelines mentioned above will now be discussed per category based on the experience gained during this research study:

- **Physical Venue:**

Physical venue refers to the physical location where the training will be conducted. This can be a room, lab, classroom, office, etc. and the following should be considered:

Location: A training venue close to training participants' places of residence will ensure promptness, regular attendance and avoid transport problems (in terms of effort and costs) so that the trainees could easily access training sessions.

Conditions: Make sure that the venue has adequate lighting and that the temperature is moderate, not too warm or too cool (if possible, use a venue with an air conditioning system to control the temperature). Moderate conditions in the venue could enhance participant involvement and concentration, and are, of course, necessary for the equipment in the venue to perform properly.

Equipment: The researcher found it better to have a small number of training participants at a specific time (not more than 10 per training session). Each participant in a group should be allocated an individual computer as well as earphones (so as not to be distracted by other agent voices in the room). Also, there is a need to have at least a projector (for demonstration purposes) and a whiteboard (for impromptu explanations), as well as additional equipment in case of equipment failure.

Layout: Choose a suitable seating arrangement that will make it easy for the facilitator to move around without creating a bottleneck, and to reach participants easily if someone needs assistance (for the purpose of this study participants sitting in rows worked quite well). Each participant should be allocated his/her own table and chair. The fact that they are interacting with agents necessitates a level of privacy and personal space.

Disturbance and comfort: To avoid disturbance it is better to set training rules in conjunction with training participants present (i.e. all cell phones must be switched off, no eating or drinking during the training session, etc.). The facilitator should ensure that the trainees are comfortable. They should be encouraged by being reassured that that they can perform the tasks, no matter what the challenges. If they experience stress in a given situation, remove them from the situation by suggesting a break and offer them a soft drink outside the venue. Also allow them to move around (within limits so as not to disturb co-trainees) as necessary to alleviate physical stress or discomfort.

- **Training:**

Training in this context refers to the acquisition of skills by computer illiterate adult users in order to perform a given computer related task with the aid of a pedagogical interface agent.

Pre-training assessment: Such an assessment will provide the facilitator with the following important information, namely who the training participants will be, what their computer literacy levels are, as well as an indication of their experiences and their learning needs.

Assistance: It is best that the facilitator keep his/her distance (especially initially) during training in order to give the trainees a chance to get involved with the agents on their own and in their own time, and also to practice their skills on their own. However, the facilitator should always be present and available, ready to assist those in need.

Training materials: The information gathered through the pre-training assessment could be used as a guideline for developing the training material. The training levels should be prepared with different skill levels in mind so as to accommodate varying computer literacy skills.

Training tasks: The individual training tasks should be as simple as possible to ensure that the learning curve is controlled in a situation where agents are introduced for the first time. In doing so, one can prevent trainees from being discouraged from using agents in future. Training tasks should also be representative of real word situations familiar to the specific

trainees. Trainees should also be given a variety of tasks to perform with the assistance of agents in order to access all of the agents' supporting abilities.

Training schedule: Adult training participants are not necessarily familiar with or used to a training setup (or they have not been in one for a long time). Therefore, the training sessions should not be too long, and too much theory should be avoided (rather make it more practical so that participants can be actively involved).

- **Agents:**

Helpfulness: The agents that will be used in training should be designed with helpfulness in mind, as that will be their main function in a training session for adult computer illiterate trainees.

Agent features: In terms of choices that have to be made in the design/selection of features of agents for these specific training purposes (cartoon vs. realistic, human vs. animal, male vs. female), the recommendation based on the results of this research study suggested that a female, human, cartoon-like agent, and a male cartoon dog, were preferred most.

Interaction/communication style: In terms of choices of agent communication styles that have to be considered (text, text and voice, physical agent and voice, voice clarity), agents communicating in colourful text, a combination of colourful text and an agent voice, as well as a physical agent talking, were well accepted by the participants. The clarity of the chosen agent's voice also had a huge impact. The female voice was preferred (although one has to admit that it will depend on the specific voice (male or female) used).

Visual appearance: A female agent, well dressed (who appeared professional), a brown dog, and text displayed in colour as well, appeared to be more attractive and more liked compared to casually dressed agents, other coloured dogs, and black text.

Movement: Movement of the eyes and mouth of agents appeared to be preferred to text being displayed on the screen.

Following these practical guidelines should improve the chances of utilising the potential of pedagogical educational agents into adult computer literacy training in a 3rd world set-up and could hopefully enhance people's chances to create a better, more educated life for themselves.

5.5 Limitations and Possible Future Research

The findings of this research study suggested that incorporating PIAs can improve adult computer literacy training, thus providing potential tools to address illiteracy problems that many developing countries are currently being confronted with.

Although the current research study seemed to be a step in the right direction, it had limitations as well. The study limitations and possible suggestions for future research are listed below:

- The SMOS is a simulated word processor system that was specifically developed for the purpose of this study. It, therefore, had limited features (i.e. number of PIAs) and functionality. The possibility of using a greater variety of PIAs in future should be considered.
- The PIAs incorporated in SMOS used natural language (English) to communicate. For this reason study participants could only consist of individuals who could understand and speak English. The possibility of utilising other participant demographics, such as young adults who cannot read or write, could be explored. There are 11 official national languages in SA. Since PIAs use natural language to communicate, the possibility of using some of these other languages should also be considered.
- Study participants received basic computer literacy training. As a result, not all the word processing tasks were included in the training - only a selected number of basic word processor tasks were considered to be relevant for the scope of the study. In future, the possibility of having participants work on complex tasks should be explored.
- Study participants consisted of individuals with little or no previous practical experience with computers. It was expected that those who lacked computer exposure would find it challenging to familiarise themselves with computers (i.e. clicking the mouse, using the keyboard to type, etc.). Hence, to avoid putting additional pressure on participants, the time taken to complete the tasks was not captured in this study as a measure of efficiency). The number of steps taken to complete a task (i.e. task effort) was the only efficiency aspect that was considered. The possibility of including more efficiency metrics should be considered in future.

5.6 Summary

This chapter gave an overview of the study. The study motivation was revisited. The significant findings were discussed in order to answer research questions and to draw conclusions. The limitations of the study and possible suggestions for future research were also discussed, while the contribution of the study was highlighted.

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Appendices

Appendix A: Ethics Clearance Letter

UFS·UV
NATURAL AND AGRICULTURAL SCIENCES

Faculty of Natural and Agricultural Sciences

11-Nov-2015

Dear **Mr Ntima Mabanza**

Ethics Clearance: **Determining the Usability Effect of Interface Agents on Adult Computer Literacy Training in the South African Context**

Principal Investigator: **Mr Ntima Mabanza**

Department: **Computer Science and Informatics (Bloemfontein Campus)**

APPLICATION APPROVED

This letter confirms that a research proposal with tracking number: **UFS-HSD2015/0593** and title: **'Determining the Usability Effect of Interface Agents on Adult Computer Literacy Training in the South African Context'** was given ethical clearance by the Ethics Committee.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2015/0593**

Please ensure that the Ethics Committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the Ethics Committee on completion of the research.
The purpose of this report is to indicate whether or not the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the Ethics Committee should be aware of.

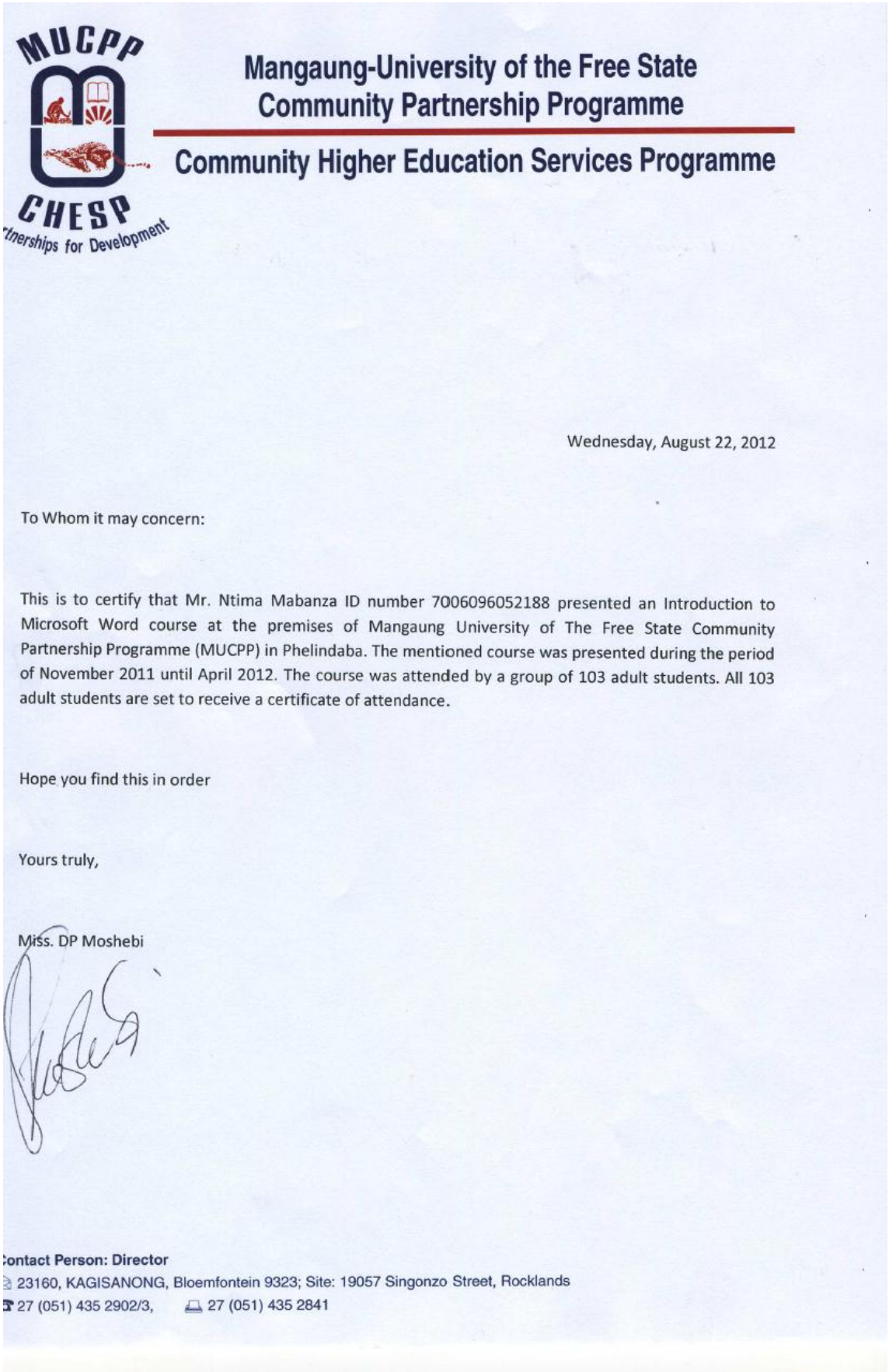
Note:

1. This clearance is valid from the date on this letter to the time of completion of data collection.
2. Progress reports should be submitted annually unless otherwise specified.

Yours Sincerely

Prof. PD (Danie) Vermeulen
Chairperson: Ethics Committee
Faculty of Natural and Agricultural Sciences

Appendix B: MUCPP Permission



Mangaung-University of the Free State
Community Partnership Programme

Community Higher Education Services Programme

Wednesday, August 22, 2012

To Whom it may concern:

This is to certify that Mr. Ntima Mabanza ID number 7006096052188 presented an Introduction to Microsoft Word course at the premises of Mangaung University of The Free State Community Partnership Programme (MUCPP) in Phelindaba. The mentioned course was presented during the period of November 2011 until April 2012. The course was attended by a group of 103 adult students. All 103 adult students are set to receive a certificate of attendance.

Hope you find this in order

Yours truly,

Miss. DP Moshebi

ontact Person: Director
23160, KAGISANONG, Bloemfontein 9323; Site: 19057 Singonzo Street, Rocklands
27 (051) 435 2902/3, 27 (051) 435 2841

Appendix C: SMS about Meeting Study Participants

You are invited to attend a meeting about the computer literacy training that will take place at MUCPP. Please note that your presence will be highly appreciated.

Appendix D: Pre-Training Questionnaire

Pre-MS WORD MODULE Questionnaire

Please fill in the relevant information /tick the relevant box(s):

SECTION 1: PERSONAL INFORMATION

1. What is your surname?

_____

2. What is your first name?

_____

3. Home language

Afrikaans		English		Sesotho		Setswana		Other, please specify	

4. What is your language competency?

ENGLISH	Under-stand	Speak
Good		
Average		
Poor		

5. What is your age group?

<20	20-30	31-40	>40

6. Select your gender?

	Male	Female	

7. What is your highest qualification?

Matric Certificate (Grade 12)		Standard 9 (Grade 11)		Standard 8 (Grade 10)		Other, please specify	

8. What is your occupation? _____

SECTION 2: COMPUTER EXPERIENCE

9. Are you scared (nervous) to learn how to use new technology?

	Yes	No	

10. Do you feel threatened when others talk about computers?

	Yes	No	

11. Do you think it is important (necessary) for you to learn how to use a computer?

	Yes	No	

12. Do you think learning about computers will give you opportunities to learn about many new things?

	Yes	No	

13. Do you think knowing how to work with computers will be useful (have an impact) in your daily life activities (tasks)?

	Yes	No	

14. Do you think knowing how to work with computers will increase your job possibilities?

	Yes	No	

15. Did you ever work with or use a computer before?

	Yes	No	

16. If 'yes' to question 15, how often did you use it?

Daily		Weekly		Monthly		Other, please specify	

17. If 'yes' to question 15, for what purpose did you use it?

Typing documents		Playing games		Sending email		Playing music		Browsing the Internet		Other, please specify	

18. If you answered 'no' to question 15:
Do you know how to switch or turn on a computer?

	Yes	No	

19. Do you know how to start up a computer correctly and open certain applications?

	Yes	No	

20. Do you know something about an operating system (e.g. Windows)?

	Yes	No	

21. Have you used an operating system (like Windows) before?

	Yes	No	

22. Do you understand how a computer works?

Yes		Uncertain		No	

23. Do you know the layout of a keyboard?

Familiar		Fairly		NO	

24. Do you know how to handle the mouse?

	Yes	No	

25. Which application programs if any, do you have experience with on a computer?

MS Word		MS Excel		Internet Explorer		Other, please specify	

26. What do you expect from this MS Word course?

_____

_____

SECTION 3: COMPUTER CHARACTERS

27. Have you ever played a game like Nintendo, etc.?

	Yes	No	

28. Have you ever played a game using your cell phone?

	Yes	No	

29. What are your attitudes towards different human being's roles played by different characters (e.g. dog, cat, robot, etc.) that are used in games or animated films?

Good		Fair		Negative	

30. Do you believe that those characters (e.g. dog, cat, robot, etc.) are able to perform whatever task or action they are supposed to perform in these games or in the movie?

	Yes	No	

SECTION 4: GENERAL

31. Would you like to be included in similar computer-related projects in future?

	Yes	No	

32. If your answer is 'YES' in question 31, please provide your contact number. _____

33. General comments:

_____

_____

Thank you very much for your input in this research.

Appendix E: Consent Form

Consent to participate in Measuring the Usability Effects of Incorporating Educational Agents on Adult Computer Literacy Training in the South African Context

This is to state that I, the undersigned (Mr. /Mrs. /Ms.)…… do hereby voluntarily agree to participate in the above-mentioned research study conducted by Mr. Ntima Mabanza from the University of the Free State.

The following are conditions of my participation in this study:

- My participation in this study is voluntary.
- I have the right to pull out from this study at any time.
- I understand that it is the system that is being tested, and not my capabilities.
- I will not be paid for taking part in this study.
- I will be given Microsoft Word basic training free of charge during this study.
- I will get a computer literacy certificate upon successful completion of the Microsoft Word basic training.
- All the information that I will provide during this study will be used for research purposes only.
- All my personal information will remain confidential and no information that identifies me will be published.
- I will respond to all the study questions as honestly as possible.

I have carefully studied the above and understand and accept this agreement.

Signature of participant

_____

Name (Please Print)

_____

Date

_____

Signature of Witness

_____

Name (Please Print)

_____

Date

_____

Appendix F: Outlines of Basic Training Materials

Ms Word

INDEX

1. Starting a computer

- Introduction to CPU box, Power button

2. Windows Basics

- Mouse, Pointing, Clicking, Double clicking, Right clicking, Dragging

2.1. Windows interface features

- Desktop, Taskbar

3. Microsoft Word (MS Word)

3.1. Starting MS Word

3.1.1. Opening MS Word 2007 Windows

- Using the start button,
- Using Microsoft Word 2007 icon on the desktop

3.2. Working with MS Word 2007 Window (lesson 1)

3.2.1. Introduction to MS Word 2007 Window Environment

- Microsoft start button, The quick Access toolbar, Title bar,
- Sizing buttons, Ribbon, The ruler, The Text area, Status bar,
- View buttons, Zoom Slider, The Vertical and Horizontal and Vertical Scroll Bars.

3.2.2. Create data by typing a text document using MS Word 2007 Window

- The cursor, Capitalizing a letter, Space Bar, Typing a text document, Insert New Text, Selecting text, Delete,
- Delete few characters, Delete few characters,
- Delete entire word or multiple words, Undo, Redo,
- Start new paragraph, Go to new line, Cut & paste,
- Copy & Paste, Microsoft Word Help Function, Saving document, Exit Word,

3.3. MS Word more Basic Features (Lesson 2)

3.3.1. Formatting a document using MS Word 2007 Window

- Open a saved file, Use spell check, Change the Font,
- Change the Font Size, Bold, Italics, Underline,
- Changing Font Color, Bullet list, Text alignment,
- Change line spacing, Find and replace, Insert picture,
- Insert date, Save document, Exit Word.

Appendix G: SMS Training Session

Please know that you will be part of Computer class that will start tomorrow Monday at 09h00 @ MUCPP. Be there on time. Send me a please call to confirm your attendance.

Appendix H: Initial Document (Main Exercise)

[This is the initial document]

Be up to date …
… Learn about computers

THE UNIVERSITY OF THE FREE STATE

Department of Computer Science and Informatics

Adult Computer Literacy

The course consists of four lectures as well as one practicales[1] session per week.

The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers.

The following topics will be coverede[2] during the course:

A discussion of computer hardware and software
Getting started with Microsoft Word
Creating a Microsoft Word document
Editing and formatting a Microsoft Word document

Facilitator: Mr. Mabanza

You can send me an email at nmabanza@gmail.com to confirm your booking.

[1] This spelling mistake was presented on purpose as the users needed to correct it.
[2] This spelling mistake was presented on purpose as the users needed to correct it.

Appendix I: Test Group Task Sheet

[Next two pages contain different tasks to be performed on the initial document]

1. Choose agent 1 [Tasks when working with agent 1]

    1.1. *Start* MS Word Simulation.
    1.2. *Open* the document "MainExercise"
    1.3. Use *spelling or grammar* tool to check if there are any errors in the document.

        a) *Correct* the errors if applicable.

    1.4. *Save* your document and name it "your name".
    1.5. *Exit* the MS Word Simulation.

2. Choose agent 2 [Tasks when working with agent 2]

    2.1. *Start* MS Word Simulation.
    2.2. *Open* the document "your name."
    2.3. *Highlight* the two first lines "Be up to date …" and "… Learn about computers"

        a) Change these two lines to *bold* and *italics.*
        b) Change the *font size* of these two lines to *20*.
        c) *Align* the second line "… Learn about computers" to the *right.*

    2.4. *Save* the changes that you have made in the document.
    2.5. *Exit* the MS Word Simulation.

3. Choose agent 3 [Tasks when working with agent 3]

    3.1. *Start* MS Word Simulation.
    3.2. *Open* the document "your name."
    3.3. *Highlight* the line "THE UNIVERSITY OF THE FREE STATE"

        a) Change the *font face* of the highlighted line to *Arial Black.*
        b) Change the *font colour* to *dark blue*

    3.4. *Save* the changes that you have made in the document.
    3.5. *Exit* the MS Word Simulation.

4. Choose agent 4 [Tasks when working with agent 4]

    4.1. *Start* MS Word Simulation.
    4.2. *Open* the document "your name"
    4.3. *Insert* the word "Course" after the word "Literacy" in the line "Adult Computer Literacy."

        a) Change *the font size* of the line "Adult Computer Literacy Course." to *18*.
        b) *Align* the line "Adult Computer Literacy Course." to the *centre*.

4.4. *Save* the changes that you have made in the document.
4.5. *Exit* the MS Word Simulation.

5. Choose agent 5 [Tasks when working with agent 5]

5.1.*Start* MS Word Simulation.
5.2.*Open* the document "your name"
5.3.*Insert* one blank line after the line "Adult Computer Literacy Course".

a) Insert a computer *picture.*
b) *Align* the picture inserted to *centre.*

5.4. *Save* the changes that you have made in the document.
5.5. *Exit* the MS Word Simulation.

6. Choose agent 6 [Tasks when working with agent 6]

6.1.*Start* MS Word Simulation.
6.2.*Open* document "your name"
6.3.*Highlight* the sentence "You can send me an email at nmabanza@gmail.com to confirm your booking."

a) *Delete* the sentence that you have just highlighted.
b) *Undo* the delete action.
c) *Redo* the delete action.

6.4. *Save* the changes that you have made in the document.
6.5. *Exit* the MS Word Simulation.

7. Choose agent 7 [Tasks when working with agent 7]

7.1.*Start* MS Word Simulation.
7.2.*Open* document "your name".
7.3.*Highlight* the sentence "The course consists of four lectures as well as one practical session per week."

a) *Cut* the highlighted sentence.
b) *Paste* the sentence that you have cut into a new paragraph and place this new paragraph after the paragraph "The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers."

7.4. *Save* the changes that you have made in the document.
7.5. *Exit* the MS Word Simulation.

8. Choose agent 8 [Tasks when working with agent 8]

8.1. *Start* MS Word Simulation.
8.2.*Open* document "your name"
8.3.*Highlight* all block of words starting from "a discussion of computer hardware and software" until "Editing and formatting a Microsoft Word document".

a) Change this highlighted block of words as a *bulled list* using the round bullet.
b) Change this *bullet list* to *italics.*

8.4. *Save* the changes that you have made in the document.
8.5. *Exit* the MS Word Simulation.

9. Choose agent 9 [Tasks when working with agent 9]

9.1.*Start* MS Word Simulation.
9.2.*Open* the document "your name".
9.3.*Highlight* the line "Facilitator: Mr. Ntima Mabanza"

a) *Align* the highlighted line to the *centre.*
b) *Underline* the highlighted line.

9.4. *Save* the changes that you have made in the document.
9.5. *Exit* the MS Word Simulation.

10. Choose agent 10 [Tasks when working with agent 10]

10.1. *Start* MS Word Simulation.
10.2. *Open* the document "your name".
10.3. *Highlight* the line "Adult Computer Literacy Course."

a) *Underline* the highlighted line.

10.4. *Save* the changes that you have made in the document.
10.5. *Exit* the MS Word Simulation.

11. Choose agent 11 [Tasks when working without an agent]

11.1. *Start* MS Word Simulation.
11.2. *Open* the document "your name".
11.3. *Highlight* all block of words starting from " the University of the Free State" until "Department of Computer Science and Informatics"

a) *Align* the highlighted block of words to the *centre.*
b) Change *the font size* of the highlighted block of words to *22.*

11.4. *Save* the changes that you have made in the document.
11.5. *Exit* the MS Word Simulation.

[This is the look of the final document]

Be up to date …

… Learn about computers

THE UNIVERSITY OF THE FREE STATE

Department of Computer Science and Informatics

Adult Computer Literacy Course

The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers.

The course consists of four lectures as well as one practical session per week.

The following topics will be covered during the course:

- *A discussion of computer hardware and software*
- *Getting started with Microsoft Word*
- *Creating a Microsoft Word document*
- *Editing and formatting a Microsoft Word document*

Facilitator: Mr. Ntima Mabanza

Appendix J: Control Group Task Sheet

[Next two pages contain different tasks to be performed on the initial document]

1. Task 1

1.1. *Start* MS Word.
1.2. *Open* the document "MainExercise"
1.3. Use *spelling or grammar* tool to check if there are any errors in the document.

b) *Correct* the errors if applicable.

1.4. *Save* your document and name it "your name".

2. Tasks 2

2.1. *Highlight* the two first lines "Be up to date …" and "… Learn about computers"

d) Change these two lines to *bold* and *italics.*
e) Change the *font size* of these two lines to *20*.
f) *Align* the second line "… Learn about computers" to the *right.*

2.2. *Save* the changes that you have made in the document.

3. Task 3

3.1. *Highlight* the line "THE UNIVERSITY OF THE FREE STATE"

c) Change the *font face* of the highlighted line to *Arial Black.*
d) Change the *font colour* to *dark blue*

3.2. *Save* the changes that you have made in the document.

4. Task 4

4.1. *Insert* the word "Course" after the word "Literacy" in the line "Adult Computer Literacy."

c) Change *the font size* of the line "Adult Computer Literacy Course." to *18*.
d) *Align* the line "Adult Computer Literacy Course." to the *centre*.

4.2. *Save* the changes that you have made in the document.

5. Task 5

5.1. *Insert* one blank line after the line "Adult Computer Literacy Course".

c) Insert a computer *picture.*
d) *Align* the picture inserted to *centre.*

5.2. *Save* the changes that you have made in the document.

6. Task 6

6.1. *Highlight* the sentence "You can send me an email at nmabanza@gmail.com to confirm your booking."

d) *Delete* the sentence that you have just highlighted.
e) *Undo* the delete action.
f) *Redo* the delete action.

6.2. *Save* the changes that you have made in the document.

7. Task 7

7.1. *Highlight* the sentence "The course consists of four lectures as well as one practical session per week."

c) *Cut* the highlighted sentence.
d) *Paste* the sentence that you have cut into a new paragraph and place this new paragraph after the paragraph "The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers."

7.2. *Save* the changes that you have made in the document.

8. Task 8

8.1. *Highlight* all block of words starting from "a discussion of computer hardware and software" until "Editing and formatting a Microsoft Word document".

c) Change this highlighted block of words as a *bulled list* using the round bullet.
d) Change this *bullet list* to *italics.*

8.2. *Save* the changes that you have made in the document.

9. Task 9

9.1. *Highlight* the line "Facilitator: Mr. Ntima Mabanza"

c) *Align* the highlighted line to the *centre.*
d) *Underline* the highlighted line.

9.2. *Save* the changes that you have made in the document.

10. Task 10

10.1. *Highlight* the line "Adult Computer Literacy Course."

b) *Underline* the highlighted line.

10.2. *Save* the changes that you have made in the document.

11. Task 11

11.1. *Highlight* all block of words starting from " the University of the Free State" until "Department of Computer Science and Informatics"

c) *Align* the highlighted block of words to the *centre.*
d) Change *the font size* of the highlighted block of words to *22.*

11.2. *Save* the changes that you have made in the document.
11.3. *Exit* the MS Word.

[This is the look of the final document]

Be up to date …

… Learn about computers

THE UNIVERSITY OF THE FREE STATE

Department of Computer Science and Informatics

Adult Computer Literacy Course

The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers.

The course consists of four lectures as well as one practical session per week.

The following topics will be covered during the course:

- *A discussion of computer hardware and software*
- *Getting started with Microsoft Word*
- *Creating a Microsoft Word document*
- *Editing and formatting a Microsoft Word document*

Facilitator: Mr. Ntima Mabanza

Appendix K: Observation Sheet

Reference: _____

Task Code: _____

Behaviour Observation Checklist

Appears calm		
Appears nervous		
Appears interested		
Appears impatient		
Appears involved		
Appears focused		
Appears motivated		
Other behaviours		
Estimate task duration		
Time taken to complete		
Task completed	Yes ☐	No ☐
Intervention type	Help ☐	Hint ☐ None ☐
Mark allocated		
Extra notes	Yes ☐	No ☐

Appendix L: Test Group Post-Test Questionnaire

Post-Test Questionnaire

The purpose of this questionnaire is to elicit your personal opinions of the agents you had worked with while carrying out different tasks for evaluation purposes. Please answer all the questions.

For <u>question 1 to question 25</u> indicate rate your opinion on a scale of 1-5, place a circle around the appropriate number, where:
1= "Strongly Disagree", 2= "Disagree", 3= "Not Sure", 4= "Agree", 5 = "Strongly Agree".

No.	LEARNING CONTENTS PROVIDED BY THE AGENTS	SD	D	NS	A	SA
1	The agents had functions and capabilities I expected it to have.	1	2	3	4	5
2	The agents used a language that was familiar to me.	1	2	3	4	5
3	The agents' hints provided all the necessary information.	1	2	3	4	5
	EFFECTIVENESS OF THE AGENTS	**SD**	**D**	**NS**	**A**	**SA**
4	The agents' hints helped me to quickly learn how to perform a particular task.	1	2	3	4	5
5	The agents' hints helped to recall the different steps involved for a particular task.	1	2	3	4	5
6	The agents' hints helped me to complete my tasks quicker.	1	2	3	4	5
7	The agents' hints were very practical.	1	2	3	4	5
8	The agents' hints assisted me to identify my mistakes when performing a task.	1	2	3	4	5
9	With the agents, it was quicker and easier for me to recover from a mistake.	1	2	3	4	5
10	I was able to understand the concepts better with the agents than I would have without them.	1	2	3	4	5
11	With the help of the agents I have managed to develop new abilities.	1	2	3	4	5
	SATISFACTION LEVELS ABOUT THE AGENTS	**SD**	**D**	**NS**	**A**	**SA**
12	The interactions with the agents were easy.	1	2	3	4	5
13	I was able to use agents successfully.	1	2	3	4	5
14	I trusted the advice from agents.	1	2	3	4	5
15	I found the agents to be intelligent.	1	2	3	4	5
16	I found the agents to be friendly.	1	2	3	4	5
17	I felt frustrated working with the agents.	1	2	3	4	5
18	I felt nervous when working with the agents.	1	2	3	4	5
19	I really had to concentrate to work with the agents.	1	2	3	4	5
20	It was exciting working with the agents.	1	2	3	4	5
21	The agents' hints helped me to feel more confident about my computer skills.	1	2	3	4	5
22	Working with the agents made me change my attitude towards computers.	1	2	3	4	5
23	My experience with these agents encouraged me to find out more	1	2	3	4	5

	about them.					
24	Based on my experience with the agents, I can encourage my friends to use them when learning about new concepts.	1	2	3	4	5
25	I would like to consider using agents when learning other concepts in real life.	1	2	3	4	5

For question 26 to question 29 select whether the statement is true of false in terms of your preference.			
26	I prefer a male agent to a female agent	☐ **True**	☐ **False**
27	I prefer a Cartoon agent to a realistic agent	☐ **True**	☐ **False**
28	I prefer a dog agent to a human agent	☐ **True**	☐ **False**
29	I prefer a text agent to a text & audio agent	☐ **True**	☐ **False**

For question 30 to question 32 Select the one agent that you liked the most based on the criterion listed below

No.	**LIKING LEVELS OF THE AGENTS' TEMPERAMENT**										
		Male text	Female text	Male Text & audio	Female Text & audio	Male cartoon dog	Female cartoon dog	Male cartoon human	Female cartoon human	Male realistic dog	Female realistic dog
30	Appearance										
31	Voice										
32	Movement										

33. For each of these agents, indicate whether you enjoyed working with them or not. Please provide any suggestions for improvement.

		Enjoyable	Frustrating	Suggestions
33.1	Male text agent			
33.2	Female text agent			
33.3	Male text & Audio agent			
33.4	Female text & Audio agent			
33.5	Male cartoon dog agent			
33.6	Female cartoon dog agent			
33.7	Male cartoon human agent			
33.8	Female cartoon human agent			
33.9	Male realistic dog agent			
33.10	Female realistic dog agent			

34. Select your first choice of agent in terms of your overall preference by putting a 'X" next to your choice **(select only one)**

34.1	Male text agent	
34.2	Female text agent	
34.3	Male text & Audio agent	
34.4	Female text & Audio agent	
34.5	Male Cartoon dog agent	
34.6	Female Cartoon dog agent	
34.7	Male Cartoon human agent	
34.8	Female Cartoon human agent	

34.9	Male realistic dog agent	
34.10	Female realistic dog agent	

35. Please give a brief reason only for your 1st choice rating in question 34 (e.g. 1st choice agent was friendly, intelligent, attractive, etc.).

1st_____

36. What was the most difficult part when you worked with agents? **(You may tick more than one option)**

Agents were distracting	
Agents were speaking too fast	
I understood very little of what the agents said	
Agents were saying the same things over and over again	
Other, please specify:	

37. What was the best part when you worked with agents? **(You may tick more than one option)**

Easier to get information needed	
Easy to understand what the agents said	
Agents' help and hints were straightforward	
Easier to figure out how to perform a particular task	
Other, please specify:	

38. Did you enjoy being part of this study? | | YES | NO | |

39. Provide reasons for your answer in question 38._____

40. How much did you learn from the study overall?

A lot	sufficient	Average	Poor	Nothing
1	2	3	4	5

41. Any general comments or suggestions:

_____

_____

42. I would like to participate in a similar research project in future. | | YES | NO | |

43. If your answer 'YES' in question 42, please provide your cell phone number_____

Thank you very much for your input in this research.

Appendix M: Control Group Post-Test Questionnaire

Post-Test Questionnaire

The purpose of this questionnaire is to elicit your personal opinions of the Microsoft Word environment you had worked with while carrying out different tasks for evaluation purposes. Please answer all the questions.

For <u>question 1 to question 23</u> indicate rate your opinion on a scale of 1-5, place a circle around the appropriate number, where:
1= "Strongly Disagree", 2= "Disagree", 3= "Not Sure", 4= "Agree", 5 = "Strongly Agree".

No.	LEARNING CONTENTS PROVIDED BY THE MICROSOFT WORD	SD	D	NS	A	SA
1	Microsoft Word had functionalities I expected it to have.	1	2	3	4	5
2	Microsoft Word environment was easy to use.	1	2	3	4	5
	EFFECTIVENESS OF THE MICROSOFT WORD HELP FUNCTION	**SD**	**D**	**NS**	**A**	**SA**
3	I found the Microsoft Word help function to be useful.	1	2	3	4	5
4	Microsoft Word help function provided me with all the necessary information.	1	2	3	4	5
5	Microsoft Word help function helped me to quickly learn how to perform a particular task.	1	2	3	4	5
6	Microsoft Word help function helped me to recall the different steps involved for a particular task.	1	2	3	4	5
7	Microsoft Word help function helped me to complete my tasks quicker.	1	2	3	4	5
8	Microsoft Word help function was very practical.	1	2	3	4	5
9	Microsoft Word help function assisted me to identify my mistakes when performing a task.	1	2	3	4	5
10	With Microsoft Word help function, it was quicker and easier for me to recover from a mistake.	1	2	3	4	5
11	I was able to understand the concepts better with the Microsoft Word help function than I would have without them.	1	2	3	4	5
12	With the help of Microsoft Word help function I have managed to develop new abilities.	1	2	3	4	5
13	Microsoft Word help function helped me to feel more confident about my computer skills.	1	2	3	4	5
14	I trusted the hint from Microsoft Word help function.	1	2	3	4	5
	SATISFACTION LEVELS ABOUT THE MICROSOFT WORD	**SD**	**D**	**NS**	**A**	**SA**
15	The interactions with Microsoft Word were easy.	1	2	3	4	5
16	I was able to use Microsoft Word successfully.	1	2	3	4	5
17	I felt frustrated working with Microsoft Word.	1	2	3	4	5
18	I felt nervous when working with Microsoft Word.	1	2	3	4	5
19	I really had to concentrate to work with Microsoft Word.	1	2	3	4	5
20	It was exciting working with Microsoft Word.	1	2	3	4	5

21	Working with Microsoft Word made me change my attitude towards computers.	1	2	3	4	5
		SD	**D**	**NS**	**A**	**SA**
22	My experience with Microsoft Word encouraged me to learn about other computer programs.	1	2	3	4	5
23	Based on my experience with Microsoft Word, I can encourage my friends to learn about new concepts.	1	2	3	4	5

24. What was the most difficult part when you worked with Microsoft Word? **(You may tick more than one option)**

Microsoft Word environment was distracting	
Microsoft Word help function instructions were too difficult to follow	
I understood very little from the Microsoft Word help function	
Other , please specify:	

25. What was the best part when you worked with Microsoft Word? **(You may tick more than one option)**

Easier to get information needed from Microsoft Word help function	
Easy to understand and follow Microsoft Word help function instruction	
Microsoft Word help function instructions were straightforward	
With Microsoft Word help function it was easier to figure out how to perform a particular task	
Other, please specify:	

26. Did you enjoy being part of this study?

	YES	NO	

27. Provide reasons for your answer in question

_____

28. How much did you learn from the study overall?

A lot	**Sufficient**	**Average**	**Poor**	**Nothing**
1	2	3	4	5

29. Any general comments or suggestions:

_____

30. I would like to participate in a similar research project in future.

	YES	NO	

31. If your answer 'YES' in question 30, please provide your cell phone number_____

Thank you very much for your input in this research.

Appendix N: Task Score Sheet

User Number:		
Tasks	**Mark**	**Scored**
Use ***spelling or grammar*** tool to check if there are any errors in the document. *Correct* the errors if applicable.	1	
Highlight the two first lines "Be up to date …" and "… Learn about computers" Change these two lines to ***bold*** and ***italics***, ***font size*** of these two lines to ***20***. ***Align*** the second line "… Learn about computers" to the ***right***.	4	
Highlight the line "THE UNIVERSITY OF THE FREE STATE" Change the ***font face*** of the highlighted line to ***Arial Black, font*** *and* ***colour*** **to** ***dark blue***	2	
Insert the word "Course" after the word "Literacy" in the line "Adult Computer Literacy." Change the ***font size*** of the line "Adult Computer Literacy Course." to ***18.*** ***Align*** the line "Adult Computer Literacy Course." to the ***centre*****.**	3	
Insert one blank line after the line "Adult Computer Literacy Course". **Insert** a computer ***picture***, ***Align*** the picture inserted to ***centre.***	3	
Highlight the sentence "You can send me an email at nmabanza@gmail.com to confirm your booking." ***Delete*** the sentence that you have just highlighted. ***Undo*** the delete action. ***Redo*** the delete action.	3	
Highlight the sentence "The course consists of four lectures as well as one practical session per week." ***Cut*** the highlighted sentence. ***Paste*** the sentence that you have cut into a ***new paragraph*** and place this new paragraph after the paragraph "The Department of Computer Science and Informatics offers Computer Literacy course suited to those with no previous experience of computers."	3	
Highlight all block of words starting from "a discussion of computer hardware and software" until "Editing and formatting a Microsoft Word document". *Change* this highlighted block of words as a ***bulled list*** **using the round bullet**. Change this ***bullet list*** **to** ***italics.***	2	
Highlight the line "Facilitator: Mr. Ntima Mabanza" ***Align*** the highlighted line to the ***centre*****.** ***Underline*** the highlighted line.	2	
Highlight the line "Adult Computer Literacy Course". ***Underline*** the highlighted line.	1	
Highlight all block of words starting from " the University of the Free State" until "Department of Computer Science and Informatics" ***Align*** the highlighted block of words to the ***centre***. Change ***the font size*** of the highlighted block of words to ***22*****.**	2	
Total	**26**	

Appendix O: Publications

To date, there have been two publications had been made from the research study discussed in the thesis. These publications are as follows:

Appendix O-1:

Mabanza, N. & De Wet, L. (2014a) 'Determining the usability effect of pedagogical interface agents on adult computer literacy training'. In: Ivanovic´, M. and Jain, L. C. eds. *E-Learning Paradigms and Applications, Studies in Computational Intelligence,* 528. Berlin: Springer-Verlag, pp. 145-182.

Appendix O-2:

Mabanza, N. & De Wet, L. (2014b) 'Adult learner interaction with pedagogical interface agents during computer literacy training', *Proceedings of the 2nd International Conference on Applied Information and Communications Technology (ICAICT2014).* Middle East College Muscat, 28-29 April. New Delhi: Elsevier, pp. 327-332

Publication (Appendix O-1)

Because of the length of the book chapter (37 pages) only the abstract and keywords are presented.

Chapter 6
Determining the Usability Effect of Pedagogical Interface Agents on Adult Computer Literacy Training

Ntima Mabanza and Lizette de Wet

Abstract A large part of the population in developing countries is technologically ignorant. Pedagogical interface agents are pieces of educational software with human characteristics that facilitate social learning. The aim of this research was an attempt to evaluate the extent to which a variety of pedagogical educational agents could assist adult learners in acquiring basic computer skills. This was done by conducting a usability test in the context of South African adult computer literacy training. A hundred and three participants were randomly assigned to either a control group or a test group, where after all participants received Microsoft Office Word training (pre-test). Only test group participants were introduced to pedagogical agents (experimental treatment). During the usability test both groups were given tasks to perform. Findings showed that computer illiterate adult users could perform better during literacy training with the assistance of educational agents when compared to only being taught through traditional teaching methods. This could open the doors to more effective ways of reaching and teaching a larger group of previously educationally disadvantaged adults in order to give them a better chance at securing employment in the labour market.

Keywords Pedagogical agents · Educational agents · Adult learners · Usability testing · Computer literacy

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M. Ivanović and L. C. Jain (eds.), *E-Learning Paradigms and Applications*, Studies in Computational Intelligence 528, DOI: 10.1007/978-3-642-41965-2_6,

Publication (Appendix O-2)

Int. Conf. on Applied Information and Communications Technology
(ICAICT-14) (327–332)

Adult Learner Interaction with Pedagogical Interface Agents During Computer Literacy Training

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Abstract—Traditional computer literacy training approaches may be challenging for people who are less educated or for those who have never been exposed to a computer before. Therefore, there is a need to find innovative ways to support this part of the population (especially in 3rd world countries) so that they can also acquire computer skills which will give them a better chance at securing employment in the labour market and enable them to be part of this modern technological oriented era. This paper explores how a Simulated Microsoft Office System (SMOS), which incorporated a range of Pedagogical Interface agents (PIAs), could assist adult computer illiterates in acquiring basic computer skills. Adult learners' perspectives about their interaction with PIAs that were incorporated in a SMOS were examined. Post-test questionnaires were given to 72 adult learners from the Mangaung University of the Free State Community Capacity Programme (MUCCP) based in Bloemfontein, South Africa. The general findings of this study demonstrated that adult learners were satisfied with the assistance that PIAs gave them in the process of learning Microsoft Office Word. This can be viewed as a promising effort towards improving the computer literacy training for adult computer illiterates in South Africa, as well as reaching and teaching a larger group of previously educationally disadvantaged adults.

Keywords: pedagogical interface agents; adult learners; computer literacy.

1. Introduction

In this digital era, computer skills have become one of the major requirements to enter the job market. Computational skills is also seen as a must have skill in order to survive in this modern technological-oriented society. Surprisingly, there is still a large part of the population in third world countries who still remain computer illiterate or who have not been exposed to a computer before. This is due to many factors, such as poverty, poor implementation of educational programmes, cultural influences, geographical factors, lack or little formal education, just to name a few. This lack of basic skills amongst the population is also creating a burden for many of the third world countries' economies, because these people cannot fully participate in the development of these countries. Many third world governments are coming up with different strategies in order to try solving the afore-mentioned challenges. The main objective of these strategies is to find means of assisting people lacking basic skills to become part of the workforce, and to improve their participation in social development initiatives in the society. One way of achieving this is to promote their skills development for employability by giving them access to the necessary learning opportunities such as basic computer literacy training.

Up to date, most computer literacy training has been conducted using traditional teaching approaches. This kind of one-to-many approach involves one skilled human instructor conducting the training session for a group of trainees. This sometimes poses an intellectual challenge for people who lack basic skills, reasons mainly being their lack of or limited formal education, never being exposed to a computer before, their usual doubt about their ability to use a computer, or they might lack self-esteem. Because of the level of their skills, they often need special attention, such as one-to-one tutoring, in order for them

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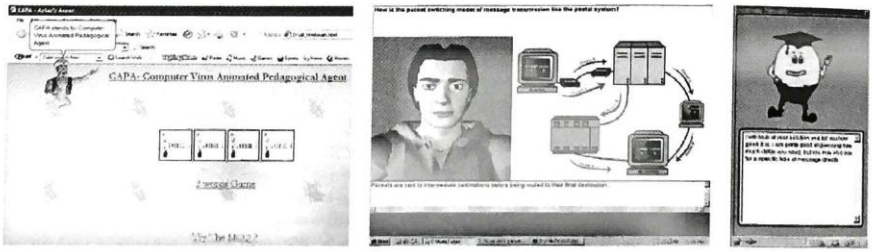
to better understand. However, it is not practical for the skilled human instructor to provide such kind of special attention for every trainee during the training session. Bearing this set of challenges in mind, very little has been done to find ways to ease the computer interaction during the training of people lacking basic skills. Coming up with ways to ease computer training in these situations will definitely assist in improving the computer literacy training experience, and can also reach more people who are facing the same dilemma. In effort to try to achieve this, many suggestions had been made. For example, Githens [1] pointed out that education providers need to develop innovative solutions for reaching larger numbers of those less familiar with technology, such as the less educated; otherwise these individuals will become further marginalized in the society. Also, Danny and Graham [2] suggested that the educational multimedia and computer-based training industries should look towards pedagogical interface agents (PIAs) as a promising solution to the challenges of modern educational environments.

1.1 Background on PIAs

PIAs are pieces of educational software with human characteristics presented on a computer screen that are able to guide users in a socially engaging manner through a multimedia learning environment [3, 4, & 5]. Adib, Aiza, Adeline, and Ketty [6] advocated that PIAs offer great promise for learning environments. Furthermore, Hanafi, Foo, Baharudin, Wong, Omar and Zuraidah [7] pointed out that PIAs are designed to facilitate and support human learning by interacting with learners in an interactive computer-mediated learning environment. In order to better facilitate computer-human's social interaction PIAs produce an emotional response. The human characteristics of PIAs can be expressed in a textual representation, a graphical representation, icons, voice, animation, multimedia, or virtual reality [8]. By means of these different representation, PIAs guide through learning by playing important pedagogical roles such as human instructors, teachers, teammates, learning companions, mentors, and so on [9, 10, 11, & 7]. PIAs can communicate with learners in natural language to guide the learners to experience learning materials better [12, & 7].

Sometimes, different terms are used when referring to PIAs. These include pedagogical agents, animated pedagogical agents, instructional agents, life like characters, or computerized agents [7, & 5].

In recent years a number of PIA systems have been developed in the field of computer teaching. A few examples of these developed PIAs include Computer Virus Educational System [13] which is used to teach students how to handle and manage computer systems in response to virus attacks, Auto Tutor [14] to help college students to learn computer literacy topics such as hardware, Operating Systems, and conceptual Physics, and Smart-Egg [15] to assist students in learning Structured Query language (SQL). These mentioned PIAs are shown in Fig 1.



(a) (b) (c)

Figure 1. (a) Computer Virus Educational System; (b) Autor Tutor; (c) Smart-Egg.

Likewise, there have been also a number of studies done in the field of PIAs to identify their usefulness in supporting learning. Most findings revealed that the use of PIAs have a potential of reducing learners' perception of the learning difficulty level of the material [16, 17, 18, & 19]. For example, Jie and Ruth [20] advocate that PIAs increase learners' motivation, satisfaction, and enjoyment and produce greater learning gains than traditional programs. However, most of these studies have focused on age groups ranging from childhood to undergraduate college students [21]. For this reason, little is known about the benefits of introducing PIAs into adult learning environments.

2. Methods

2.1 Participants

Participants in this study consisted of 72 adult learners from the Mangaung University of the Free State Community Capacity Programme (MUCCP) based in Bloemfontein, South Africa. Forty three percent of the sample was male and

57% female. Their ages varied : 17% were younger than 20 years, 50% between 20 and 30, 29% were 31 to 40 years old, and 4% were older than 40.

2.2 Instruments

Questionnaires and a Simulated Microsoft Office System (SMOS) are the two main instruments that were used to gather data needed for this study. Two types of questionnaires were introduced, namely pre-training and post-test questionnaires. Pre-training questionnaires were used to collect demographic information, and the level of the computer familiarity. The post-test questionnaire was used to collect information about participants' perceptions concerning their training experiences (using) with PIAs. The SMOS is a simulated Microsoft Office Word environment developed by Potgieter [22]. This system incorporates 10 different types of PIAs. These 10 PIAs are shown in Fig 2 below.

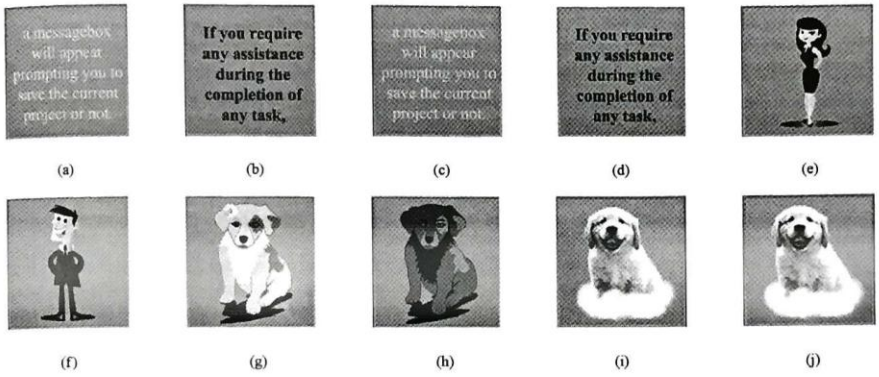


Figure 2. (a) Female text agent; (b) Male text agent; (c) Female text & audio; (d) Male text & audio; (e) Female cartoon human; (f) Male cartoon human; (g) Female cartoon Dog; (h) Male cartoon Dog; (i) Female realistic Dog; (j) Male realistic Dog.

The choice of which PIAs to include in this study (Fig. 2) was based on many factors. People may react differently to different types of agents. Jie and Ruth [20] pointed out that it is challenging to design PIAs that behave much like a sensitive and effective human tutors. Therefore, the authors were of the opinions that combining different types of PIAs (i.e. gender, voices, and appearances) would be more advantageous than just using a specific kind of PIA. The main purpose of all these PIAs consist of collaborating with adult learners during their training by giving them necessary tips on how to perform a particular task. This is done with the idea to try to ease the difficulty of learning materials for adult learners. All adult learners received initial training in order to familiarize them with the various PIAs. Afterwards, each of them was given various Microsoft Office Word tasks that he/she had to perform in collaboration with the different PIAs as part of the learning process. The Fig 3 shows the SMOS interface as well as the interaction between a participant and a female realistic dog during the training.

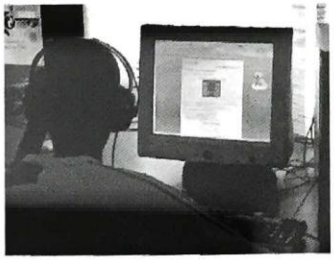


Figure 3. A participant interacting with a female realistic dog agent

3. Data Presentation and Analysis

Data collected by means of a pre-training questionnaire included educational level, occupation, the relevance of computer skills in their life, and computer exposure, including attitude towards computer characters.

With regards to educational level, 65% of the participants had obtained a matric certificate, 25% indicated grade 11 as their highest qualification, a further 7% passed grade 10, 1% had passed grade 9, and the other 1% did not indicate their education level. A total of 24% worked on a voluntary basis, while the other occupations of participants included cleaner (7%), sewing (2%), self employed (3%), student (5%), care worker (3%), skills coach (2%), and FM presenter 2%. The rest did not indicate their occupations.

Participants were also asked to give their opinion about the significance of computer skills in their life. The vast majority (97%) agreed that it was important to learn how to use a computer. All participants (100%) agreed to the following:

- Learning about computers will give them opportunities to learn about new things.
- Knowing how to work with computers will be have an impact on their daily life activities.
- Working with computers will increase their jobs opportunities.

Data about the participants' computer exposure revealed that 51% had used the computer before and the other 49% did not. For those who had been exposed to computers, 42% used it monthly, 26% weekly, 26% daily, 3% occasionally, and 3% seldom. For those participants who had used computers before, they used it for many reasons such as for typing a document (62%), playing games (32%), sending e-mail (16%), playing music (38%), and browsing the internet (22%).

With regards to participants who had never been exposed to computers before, 61% of them indicated that they knew how to switch on a computer, while 39% did not know how.

Participants were asked about their views on different human beings being represented by different characters (i.e. dog, cat, robot, etc.) – a frequently used practice in games or animated films. Fifty four percent of participants were positive about it, the other 36 % were fairly positive, while 10% were negative about the idea.

After completing their tasks, participants filled in a post-test questionnaire in which they reported their perceptions about the various agents used during training process. Some of the results are shown in Fig 4.

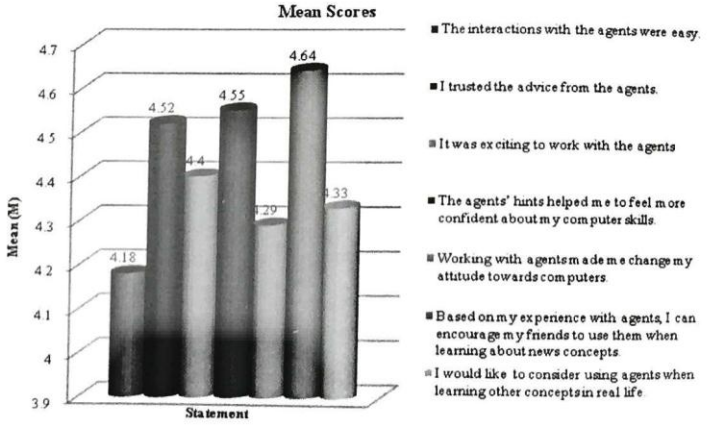


Figure 4. Participants' opinions about their interaction with PIAs

Data displayed in Fig 4 show that all mean scores in terms of the participant reactions to the agents were above average, and therefore their reactions were positive. The four highest mean scores were from the following statements: (i) Based on my experience with agents, I can encourage my friends to use them when learning about news concepts

(4.64), (ii) the agents' hints helped me to feel more confident about my computer skills (4.55), (iii) I trusted the advice from the agents (4.52), and (iv) it was exciting to work with agents (4.40). The other statements performed good as well, with mean scores 4.33 (I would like to consider using agents when learning other concepts in real life), 4.29 (Working with agents made me change my attitude towards computers), and 4.18 (The interaction with the agents were easy). The results indicated that almost all the participants enjoyed PIAs' assistance during the learning process, which was a positive indication towards introducing agents in these circumstances.

4. Findings, Discussion & Conclusion

The findings of the research study can be summarized as follows:

- Participants recognized that there is a necessity for them to possess computer skills.
- Participants were aware that computer skills would give them more opportunities to enter the job market, and improve their daily living standard.
- Participants recognized that PIAs can facilitate their computer training experiences.
- Participants' experiences with PIAs motivated them to find out more about computers, change their attitudes towards computers, and improve their confidence in their computer skills.
- The PIA experience motivated participants to encourage their friends to use PIAs when learning about news concepts.

As pointed out in subsection 1.1, PIA systems are being used in computer instructional environments to support the teaching of various topics such as computer viruses [13], general computer literacy topics [14], and SQL programming [15]. Literature reviewed showed that previous studies about PIAs especially in the computer instructional environments were done on age groups ranging from childhood to undergraduate college students. Consequently little is known about the incorporation of PIAs into adult computer literacy training [23]. Therefore, in this study, the focus was on adult computer illiterate participants of various ages that could read and write, but with no experience with PIAs (and little experience with computers, if any). Furthermore, findings of previous studies (i.e. 16, 17, 18, & 19) revealed that PIAs has the potential to promote learning. This implies that PIAs can assist in reducing learners' perception of the learning difficulty level of learning material. Although the population group in this study differed from previous studies, the findings were in line with these previous findings (13, 14, 15, 16, 17, 18, & 19). It is evident that adult learners were satisfied with their experiences of working with PIAs during their computer learning process.

In summary, the overall results from the findings have shown that PIAs can have potential to enrich computer training experiences for adult computer illiterates. This proves that PIAs can positively influence changes in adult computer illiterates' knowledge, attitude, and ambition. Furthermore, this finding can assist in bringing useful transformations to improving computer training for adult computer illiterates. Thus, the methods used in this study can be viewed as a promising effort towards improving the computer literacy training for adult computer illiterates in South Africa, as well as in other third world countries.

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Author Biographies

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Lizette de Wet obtained her Ph.D. in Computer Information Systems from the University of the Free State (UFS) in South Africa. She has 17 years of experience in the academic environment. Currently, Dr. de Wet is a senior lecturer in the Department of Computer Science and Informatics at the UFS. She was awarded the Prestige Award in Teaching and Learning from the Faculty of Natural and Agricultural Science at the UFS in 2009. As far as research is concerned, she has a passion for Human-Computer Interaction. Her latest research involves the influence of interface agents on teaching computer literacy to adults, as well as on Biometrics as a means of usability testing. She was also involved extensively in research on the Electronic Patient Record, as well as on multicultural Web-design.

Appendix P: Interview Sheet

Interview Questions

What was your experience with the system[3] that you used during the training?

Do you think the system has the ability to facilitate training for people who have little knowledge of computers?

What are the main problems and challenges that you have experienced while using the system?

Based on your experience with the system, what did you like about it?

Based on your experience with the system, do you have any recommendations for improvements?

[3] The term 'system' referred to the respective system that a participant used during the user testing. In the case of test group participants, it referred to SMOS which incorporated 10 PIAs. For the control group participants, it referred to the MS Word Environment.

Appendix Q: Conversation Script

After a participant launched the SMOS, the particular agent that was selected appeared (see Figure 3.6). The following provide examples of dialogue between an agent (A) and a participant (P).

Example 1

A: Hi, I will be assisting you with the tasks you need to complete today. If you require any assistance during the completion of any task, use the drop-down-list control at the top of the screen and select the task that you need the assistance for. For example, when you need help to 'copy', click on the drop-down-list and select the option 'copy'. Good luck!

P: Participant clicks on the drop-down-list control and then selects the option '*delete*'.

A: To delete text means to erase text from a document.

To delete text, select the text that you want to delete, press either the delete or backspace button on the keyboard.

Example 2

P: Participant clicks on the drop-down-list control and then selects the option '*Font colour*'.

A: Font colour is the colour in which texts are displayed.

To change the font colour of a text, first select the text that needs to be changed, now select the font colour icon in the font box above, and finally, select the desired colour and click the okay button.

Example 3

P: Participant clicks on the drop-down-list control and then selects the option '*underline*'.

A: Underline means to draw a line under a word or a phrase.

Select the text you wish to underline, now click the underline icon on the font block above. You can also use short cut keys by holding down the control key and press the U key.

Note: if there is any need to replay, pause, or stop the instruction, a participant can do that by using the control buttons (play, pause and stop) as shown in Figure 3.8.

Summary

The problem of high computer illiteracy amongst adults in 3rd world countries, such as South Africa (SA), is preventing these individuals from becoming part of workforce as computer skills have become one of the major requirements to enter the job market. The other challenge for this group is that most of the current adult computer literacy training is conducted using approaches such as conventional training and e-learning. Often these approaches pose intellectual challenges to people who have never been exposed to a computer. In line with this, this research study was conducted in an effort to find new approaches to assist adult computer illiterate people, specifically in SA, to acquire the skills necessary (i.e. basic computer literacy) to promote employability and the improvement of their lives. The use of Pedagogical Interface Agents (PIAs) is one example of such a new approach.

Over the years, many research studies on the potential of PIAs in promoting learning have been carried out. The results obtained from these studies showed that PIAs can improve student learning, engagement and motivation. However, most of these studies have focused on age groups ranging from childhood to undergraduate college students. Little attention has been paid to the use of PIAs in adult learning, and in computer literacy training, specifically in the word processing environment.

The aim of this research study was to establish, through user testing, whether the incorporation of a variety of PIAs could improve and facilitate the computer literacy training (specifically in a word processing environment) for adult computer illiterates in SA. To achieve this aim, Simulated Microsoft Office Word System (SMOS), a simulated word processor system incorporating 10 PIAs (varying in terms of appearance, gender, voice and reality) was used in conjunction with MS Word to collect data needed for this research. A summative usability evaluation was performed in this study. The pragmatist paradigm was selected as a suitable paradigm for the current study. This research study employed the convergent parallel mixed-methods design. Study participants consisted of a group of adults from Mangaung-University of the Free State Community Partnership Programme (MUCPP) who could understand and speak English, had little or no formal education and had never been exposed to a computer before. In order to better assess the usability of the 10 PIAs incorporated in SMOS, participants were divided into two groups, namely the test group (trained with SMOS, which incorporated PIAs) and the control group (trained with MS

Word, without PIAs). Afterwards, participants from both groups were given 11 basic word processing tasks to complete using their respective systems (i.e. SMOS or MS Word) as part of the user assessment. In this study, reliability and validity were established through the use of multiple sources of data, which were directly linked to the study aims and objectives. A pilot study was conducted to check the appropriateness of data collection techniques used in this study. The user test performed in this study sought to measure three usability attributes, namely efficiency (measured by means of task efforts), effectiveness (measured by means of both individual and total number of errors) and satisfaction (measured by means of the user experience questionnaire related to the amount learnt from the study overall, enjoyment in being part of the study, and willingness to participate in a similar study in future). Observations and interviews were used to complement and better understand the effectiveness, efficiency and satisfaction data.

All collected user test data were analysed using comparative statistical test techniques. The comparative analyses' results showed that test group participants (trained with SMOS, which incorporated PIAs) outperformed the control group participants (trained with MS Word, without PIAs) in both efficiency and effectiveness. With regard to the satisfaction, no difference was noted between participants from the two groups.

Based on the findings of this study, it can be inferred that the use of PIAs could assist in overcoming many problems faced by adult computer illiterate users during computer literacy training in a 3rd world environment like in SA. However, it is suggested that key aspects, such as characteristics of adult learners, PIAs' external observable characteristics, and adult learners' satisfaction/ability to use the system, need to be systematically explored.

Opsomming

Die kwessie van hoë vlakke van rekenaarongeletterdheid onder volwassenes in 3de wêreldlande, soos Suid Afrika (SA), verhinder hierdie individue om deel te word van die werkerskorps aangesien rekenaarvaardighede een van die hoofvereistes geword het t.o.v. toetrede tot die beroepswêreld. Die ander uitdaging vir hierdie groep is dat die meeste volwasse rekenaargeletterdheid-opleidingsprogramme tans van konvensionele opleidingsbenaderinge gebruik maak. Hierdie konvensionele benaderinge hou dikwels intellektuele uitdagings in vir persone wie nog nie vantevore aan ŉ rekenaar blootgestel is nie. In lyn hiermee, is hierdie navorsingstudie gedoen in ŉ poging om nuwe benaderinge te kry om volwasse rekenaarongeletterde persone, spesifiek in SA, te help om die nodige vaardighede (bv. basiese rekenaargeletterdheid) aan te leer ten einde indiensneming te bevorder en hul lewens te verbeter. Die gebruik van *Pedagogical Interface Agents* (PIAs) is een voorbeeld van so ŉ nuwe benadering.

Oor die afgelope paar jaar is verskeie navorsingstudies gedoen oor die potensiaal van PIAs om leer te bevorder. Die resultate verkry uit hierdie studies wys dat PIAs wel studente-leer, betrokkenheid en motivering kan bevorder. Die meeste van hierdie studies het egter gefokus op ouderdomsgroepe tussen kindertyd tot voorgraadse kollege-studente. Baie min aandag is gegee aan die gebruik van PIAs in volwasse leer, en in rekenaargeletterdheid-opleiding, spesifiek in die woordverwerker-omgewing.

Die doel van hierdie navorsing was om, deur gebruikertoetsing, vas te stel of die inkorporering van ŉ verskeidenheid PIAs rekenaargeletterdheidsopleiding (spesifiek in ŉ woordverwerker-omgewing) vir volwasse rekenaarongeletterdes in SA kan verbeter en fasiliteer. Om hierdie doel te bereik is Simulated Microsoft Office Word System (SMOS), ŉ gesimuleerde woordverwerkingstelsel wat 10 PIAs (verskillend t.o.v. voorkoms, geslag, stem en werklikheid) gebruik, tesame met MS Word gebruik om data te vang vir hierdie navorsing. ŉ Summatiewe bruikbaarheidsevaluering is in hierdie studie gedoen. Die pragmatiese paradigma is beskou as die mees geskikte paradigma vir die huidige studie. Die navorsingstudie het ook gebruik gemaak van konvergente parallel gemengde-metodes navorsing. Deelnemers aan die studie het bestaan uit ŉ groep volwassenes van Mangaung-University of the Free State Community Partnership Programme (MUCPP) wie Engels kan praat en verstaan, baie min of selfs geen formele onderrig gehad het nie, en nog nooit tevore aan ŉ rekenaar blootgestel is nie. Ten einde die bruikbaarheid van PIAs geinkorporeer in

SMOS beter te assesseer is deelnemers in twee groepe verdeel, naamlik die toetsgroep (opleiding met SMOS, wat PIAs insluit) en die kontrolegroep (opleiding met MS Word, sonder PIAs). Deelnemers van beide groepe het 11 basiese woordverwerkertake gekry om te doen deur gebruik te maak van hul onderskeie stelsels (SMOS of MS Word) as deel van die gebruikerassessering. In hierdie studie is betroubaarheid en geldigheid bevestig deur gebruik te maak van verskeie databronne, wat direk verwant is aan die studie se doelstellings en doelwitte. ’n Loodsstudie is gedoen om die gepastheid van die datavangmetodes in hierdie studie te meet. Die gebruikertoets wat in hierdie studie gedoen is moes drie bruikbaarheidskenmerke meet, naamlik bekwaamheid (gemeet d.m.v. taak pogings), effektiwiteit (gemeet deur beide individuele en totale getal foute) en bevrediging (gemeet d.m.v. ’n gebruiker-ervarings vraelys wat verband hou met die totale leer uit die studie, genot om deel te neem en bereidwilligheid om in die toekoms weer aan so ’n studie deel te neem). Waarnemings en onderhoude is gebruik om die bekwaamheids-, effektiwiteits- en bevredigingsdata te komplimenteer en beter te verstaan.

Alle gebruikertoetsdata wat vasgelê is is ontleed deur vergelykende statiestiese toetstegnieke. Die resultate van die vergelykende analise dui aan dat die toetsgroep-deelnemers (opleiding met SMOS, insluitend PIAs) baie beter gevaar het as die kontrolegroep-deelnemers (opleiding met MS Word, sonder PIAs) in beide bekwaamheid en effektiwiteit. Met betrekking tot bevrediging is geen onderskeid opgemerk tussen deelnemers van die twee groepe nie.

Gebaseer op die bevindinge van die studie kan dit afgelei word dat die gebuik van PIAs wel kan bydra om baie van die probleme wat volwasse rekenaar-ongeletterde gebruikers tydens rekenaargeletterdheidsopleiding in ’n 3de wêreld omgewing soos SA ondervind, te oorkom. Daar word egter voorgestel dat hoofaspekte, soos die eienskappe van volwasse leerders, PIAs se eksterne waarneembare eienskappe en volwasse leerders se bevrediging/vermoë om die stelsel te gebruik, stelselmatig ondersoek moet word.