

**THE RELATIONSHIP BETWEEN STUDENTS' E-SKILLS
COMPETENCIES AND THE USABILITY PROBLEMS THEY
EXPERIENCE WHEN USING A LEARNING MANAGEMENT SYSTEM
IN AN OPEN DISTANCE LEARNING ENVIRONMENT**

by

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I declare that

“The relationship between students’ e-Skills competencies and the usability problems they experience when using a Learning Management System in an Open Distance Learning environment”,

is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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Abstract

Computer literacy or e-Skills is one of the recommended competencies for graduateness besides analytical, problem solving, writing, social awareness and responsibility skills. As Learning Management Systems become ubiquitous at universities around the world, electronic skills are increasingly becoming more important for students. Identifying usability problems experienced by students with varying e-Skills in an Open Distance Learning (ODL) higher education institution can contribute to an understanding of the learning challenges that students face. This research used a simulated, competence-based assessment to evaluate the e-Skills competencies of first year university students at a South African open distance learning university, the University of South Africa. Based on their performance in the assessment, students were categorised according to an e-Skills proficiency framework consisting of four levels: Digital Awareness, Digital Literacy, Digital Competence and Digital Expertise. The research then investigated the relationship between the usability problems experienced by participants with varying e-Skills competence levels when using a Learning Management System, and their e-Skills proficiency through usability testing and eye tracking. Eye tracking visualisations, heat maps and gaze plots, used with usability testing showed differences in the search patterns and the efficiency with which students with different e-Skills levels use the learning management system. Although more usability problems were encountered by students with lower levels of e-Skills proficiency, some usability problems were faced by students across all four levels. The study shows that it is necessary to consider the differences in learners' digital proficiency levels when designing learning management systems in order to minimise usability problems. This is very critical in a distance learning environment where there is very little physical contact, if any, between the institution and the student.

Key terms: Learning Management System (LMS), Open Distance Learning (ODL), E-Skills, Usability, Usability evaluation, Eye tracking and User-centred design.

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Chapter 1: Introduction

1.1 Introduction

As learning management systems (LMSs) become ubiquitous at universities around the world electronic skills (e-Skills), also referred to as information and communication technology (ICT) skills or computer literacy, are increasingly becoming an important factor for students' learning (Lonn, Teasley & Krumm 2011). LMSs, which are Internet based systems, integrate a wide range of services such as student enrolment, assignment submission, announcements, and online discussion forums. This research investigated the relationship between students' e-Skills competencies and the usability problems they experience when using a LMS in an Open Distance Learning (ODL) environment.

Inadequate Web knowledge and computer illiteracy are the most frequently identified barriers to Web use (Lee, Chen & Hewitt, 2011). In a diverse, multi-cultural ODL institution such as the University of South Africa (Unisa), users' computer and Web skills vary significantly (Pretorius, Van Biljon & De Kock, 2010). Usability of the LMS interface is associated with how easy it is to use, learn, remember, as well as how pleasant it is for the users to use it, the errors they make, and the ease with which they recover from the errors (Rogers, Sharp & Preece, 2011; Nielsen, 1994).

The number of studies devoted to identifying usability issues of LMSs is insufficient, and more research on e-Skills that use methodical and valid approaches is required (Alexander, Lotriet & Matthee, 2009; Ardito, Costabile, Marsico, Lanzilotti, Levialdi, Roselli & Rossano, 2006). Usability testing and eye tracking were used in this research to investigate the usability problems that students with different e-Skills proficiency experience when using an LMS. A simulated competence-based e-Skills assessment was first used to determine the e-Skills of first year students. The assessment (Appendix 1),

performed in the computer laboratory, required each user to perform exercises in Microsoft Word, Powerpoint, Excel, e-mail and Internet Explorer. Based on their performance, the students were then grouped into the four digital proficiency levels of a Digital Proficiency Framework, namely, Digital Awareness, Digital Literacy, Digital Competence and Digital Expertise (ECDL Foundation, 2011). Usability testing and eye tracking conducted at the Human-Computer Interaction (HCI) laboratory was used to identify the usability problems experienced by students with different e-Skills proficiency. An analysis of the collected evidence showed how e-Skills proficiency relates to usability problems experienced by users.

1.2 Problem statement

Since the beginning of 2013, any student registered for an undergraduate degree at the University of South Africa (Unisa), the ODL institution where this study was undertaken, is required to register for and to successfully complete one signature module. A signature module is a compulsory online course which requires students to participate in online learning and assessment. No printed study material is provided for these signature modules. With the introduction of signature modules and as the university moves towards online learning, e-Skills will become even more important for students.

In an open distance learning institution such as Unisa, students' ICT skills are diverse. While some users are experts, others lack the most basic computer skills. The Unisa Learning Management System (LMS), myUnisa, provides functions for students to access course content and communication facilities such as online discussion forums and e-mail facilities. Instructors use LMSs for pedagogic functions such as posting learning material, making announcements and communicating with students. Usability problems encountered when using the LMS can slow students down; impede the use of the LMS and can even make it inaccessible. ICT skills or e-Skills have been found to be an important factor for students', to the point where a severe lack of ICT skills can make the LMS inaccessible (Pretorius & Van Biljon, 2010). Identifying the usability problems experienced by users with varying e-Skills levels when using the LMS, can assist systems designers in applying user-centred design principles and ensuring improved access to the LMS. Competency

evaluation such as assessment of students' e-Skills can contribute to identification of students who need assistance.

ODL is a multidimensional concept aimed at bridging the time, geographical, economic, social, educational, and communication distance between a student and the institution; a student and academics; student and courseware, and student and peers (Unisa ODL policy, 2008). ODL learning opportunities are underpinned by principles of lifelong learning and flexibility (Unisa 2015 Strategic Plan, 2010). In the context of a global economy, ICT Skills are an essential graduate skill (Miliszewska, 2008). ODL institutions should not only promote equity of access to education, but also provide appropriate student interventions aimed at bridging the gaps in students' academic readiness for higher education for students admitted to the institution that need support (Daniel, Kanwar & Uvalić-Trumbić, 2009).

1.3 Research questions and objectives

1.3.1 Research questions and sub-questions

In view of the problem statement in Section 1.1, the main research question was:

What is the relationship between the e-Skills competencies of first year university students and the usability problems they experience when using a Learning Management System in an Open Distance Learning environment?

In order to answer this question, the following sub-questions were answered during the study:

- 1 What are the e-Skills competencies of first year university students?
- 2 What are the usability problems experienced by first year university students when using a LMS in an ODL environment?
- 3 How do the usability problems identified, relate to the e-Skill levels of the users?
- 4 What does eye tracking reveal about the relationship between the usability problems and the e-Skills competencies of the students?

- 5 How can this information assist e-Learning designers to develop usable LMS user interfaces that cater for varying e-Skill levels?

1.3.2 Research purpose and objectives

The research objectives were to:

- 1 Ascertain the e-Skills competencies of first year university students
- 2 Determine the usability problems experienced by first year university students using a LMS in an ODL environment,
- 3 Ascertain how the usability problems identified relate to the e-Skill levels of the students,
- 4 Find out what eye tracking reveals about the relationship between the usability problems and the e-Skills competencies of the students, and
- 5 Examine how this information can assist e-Learning designers to develop usable LMS user interfaces that cater for varying e-Skill levels.

1.3.3 Scope and limitations

Only desktop eye tracking evaluations of the LMS were carried out for this study. Mobile eye tracking evaluations and assistive technologies such as screen readers were considered to be outside the scope of the study. The research focused on highlighting the effect of e-Skills on the usability of the LMS and therefore on learning. To achieve this, the usability problems that students with varying e-Skills experience when using the LMS were investigated using one module, End User Computing, as a case study. Three aspects of the LMS were tested; sending an e-mail with an attachment, finding a tutorial letter for the module and posting a comment on the online discussion forum. Based on the analysis of usability data obtained through usability testing, eye-tracking, video recordings, post-test questionnaire and interviews, usability problems experienced by users with varying e-Skills were identified and analysed.

1.4 Research methodology and design

Multiple sources of evidence were considered to be beneficial for this research. As noted by Yin (2009), good case studies benefit from obtaining evidence from different sources. Data collection on e-Skills competence was undertaken using a simulated competence-based assessment (Appendix 1). Data on the usability problems that the students experience when using the LMS was collected in the Human-Computer Interaction (HCI) laboratory using eye tracking equipment, and through direct observation, interviews and questionnaires. The researcher observed the participants in the HCI laboratory as they carried out specific tasks using the LMS, and a narrative report was prepared based on the observations. Audio and video recordings as well as a post-test interview provided additional information. Eye tracking recorded the position of the students' eyes on the screen as they carried out the tasks, providing insights regarding the usability problems experienced by students using the LMS. This information was then related to the students' e-Skills proficiency.

This study adopts a case study research design. A hypothesis about the relationship between students' e-Skills competencies and the usability problems that they experience when using a LMS in an ODL environment was investigated. A hypothesis is a specialised quantitative research question in which the researcher makes predictions about relationships among phenomena based on theory, previous research or other rationale about the relationships in advance of the actual research (Tashakkori & Teddlie, 2008).

The mixed method selected for the study requires that the researcher collects and analyse data, integrates the findings, and draws inferences using both qualitative and quantitative methods in a single study or program (Tashakkori & Teddlie, 2008). The research's pragmatic philosophical orientation is relevant because pragmatism is most associated with the mixed method (Bryman, 2006). Pragmatists acknowledge that research occurs in a social, historical and political context and advocate the use of whichever methodological approach required to answer the research questions, whether quantitative, qualitative or both (Creswell, 2009).

1.5 Significance and context of the study

In South Africa, the provision of distance learning programmes in higher education gives access to education to students for whom full-time university education is inappropriate, unaffordable or inaccessible (DHET, 2012). The diversity in the profile of students in ODL institutions indicates the role that distance education plays in providing a second chance and an alternative access to higher education and an increase in learning opportunities, which includes professional upgrading for working adults. However, many students in distance education institutions take a long time to complete and many of them drop out or fail and do not re-register. Addressing drop-out rates and increasing graduation rates is a pressing concern for the Department of Higher Education and Training (DHET, 2012). Access to the LMS means access to course material and other facilities such as announcement boards and discussion forums. LMS facilities such as online discussion forums can improve teaching and learning, enhance communication among students and between students and instructors.

South Africa's National Plan for Higher Education advocates for the creation of a learning society that draws in people of all ages, and from all walks of life, to give them the opportunity to advance, develop and enrich themselves, both intellectually and materially (Department of Education, 2001). In South Africa, distance education programmes enrolled 316 349 students in 2009, which was 37.8% of all higher education students. In 2009, the headcount enrolment was 279 744, accounting for 88% of all higher distance education enrolments (DHET, 2012). The headcount enrolment at Unisa increased to 356 940 in 2012.

Unisa is the sole dedicated distance higher education institution in South Africa and the oldest and largest university in South Africa. Given Unisa's significant position in the enrolment of distance education students in higher education in South Africa, this study is significant and relevant in that it can contribute to our understanding of the challenges that university students at the institution face in their learning due to e-Skills competencies. This can also provide insights that can contribute to determining ways of eliminating usability

problems, increase user satisfaction and contribute towards continued and enhanced usage of the LMS.

In open distance learning, “open learning” includes flexibility of learning provision, the removal of barriers to learning and the recognition of prior learning experience (DHET, 2012). It is however important that students’ levels of academic preparedness be assessed so that appropriate support systems be provided for students who require help to address academic skills gaps (Daniel et al., 2009). The removal of barriers to learning and provision of relevant learner support can only occur when relevant information is available to identify the problems and hence the support required. In addition, since students registered for the End User Computing module used in this case study come from different faculties in the university, their diversity and the predominantly online delivery of the module add to the research’s significance.

1.6 Structure of the dissertation

There are six chapters in the dissertation. Figure 1.1 gives an overview of the structure of the dissertation. The first chapter introduces the study. The literature is reviewed in Chapter 2 where usability and usability evaluation methods are deliberated and the role of usability in user centred design is delineated. The e-Skills and e-Skills Proficiency framework are also discussed in this chapter and the usability problems related to the e-Skills competence levels. Chapter 3 describes the research methodology and design used in the study. The findings of the research are presented in Chapter 4 and analysed in Chapter 5. The conclusion is given in Chapter 6.

Structure of the dissertation

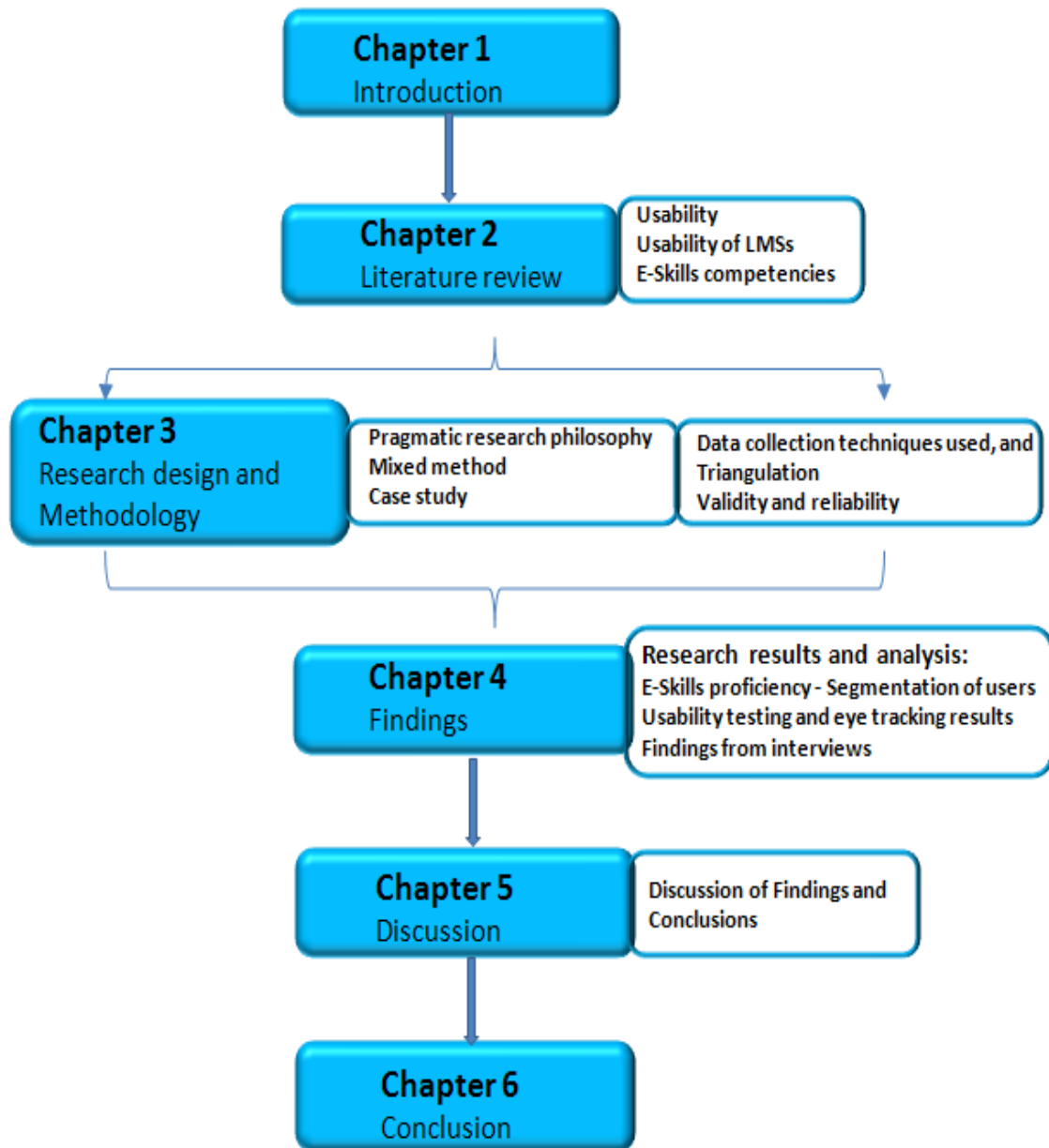


Figure 1.1: Overview of the structure of the dissertation

Chapter 2: Literature Review

2.1 Introduction

In this chapter published scholarly research relevant to this research is presented. Related literature is outlined and examined in relation to the study's research questions. This chapter is organised as follows: Section 2.2 outlines what usability is, and discusses usability evaluation methods in the context of system development and user-centred design. Section 2.3 discusses usability of learning management systems. The ODL environment, Learning Management Systems (LMSs) and usability problems in LMSs are also explained. E-Skills competence and the e-Skills Proficiency Framework used in the study are outlined in section 2.4. Section 2.5 discusses the classification of e-Skills in the context of LMSs and section 2.6 concludes the chapter.

2.2 Usability

2.2.1 What is usability?

Usability is now widely recognized as critical to the success of an interactive system or product (ISO/IEC FDIS 9126, 2000; Maguire, 2011; Nielsen & Pernice, 2009; Schiessl, Duda, Thölke & Fischer, 2003). A traditional view of usability is that it is the attributes of the user interface that makes a product or system easy to use (Bevan, 2009). The International Organisation for Standardisation (ISO) describes usability is the capability of the software product to be understood, learned, used and be attractive to the user, when used under specified conditions (ISO, 2008).

There are various ways in which usability has been described. As early as the '90s, Redish and Dumas' (1999) noted that usability means that the people who use the product can quickly and easily accomplish their own tasks. These definitions point to some important factors; firstly that usability focuses on users, that users use products to accomplish tasks

and be productive, and that users subjectively decide whether a product is easy to use. An internationally accepted definition of usability is the extent or degree to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction, in a specified context (ISO, 2008). Effectiveness refers to the accuracy and completeness with which users achieve specified goals, while efficiency refers to the resources used in relation to the accuracy and completeness with which users achieve those goals. Satisfaction is the freedom from discomfort, and positive attitudes that the user has towards the use of the system.

Usable systems are characterised by efficiency, learnability, memorability, low error rate and satisfaction (ISO, 1998; Nielsen, 1994). Shackel and Richardson (1991) identified effectiveness, learnability and flexibility as important for a usable system. They also indicated that the system should have acceptable levels of human cost in terms of tiredness, discomfort and frustration resulting in continued and enhanced usage of the system. Satisfaction in the ISO definition of usability refers to similar characteristics.

2.2.2 Measures of usability

Usability can be measured by assessing the Satisfaction, Efficiency and Effectiveness levels (Hopkins, 2011). Satisfaction is assessed by measuring the subjective ratings of “ease of use” and ratings of the system’s functionality by the users. Efficiency relates to the effort required to achieve the goals, and effectiveness measures the success in achieving the goals (Hopkins, 2011). Figure 2.1 shows the usability components and measures.

This is in line with Jokela, Livari, Matero and Karuka’s (2003) definition that usability of a system is its ability to function effectively and efficiently while providing subjective satisfaction to its users. It is also similar to Nielsen’s definition that usability is a multi-dimensional property of a user interface that is associated with five usability attributes, learnability, efficiency, memorability, (number of) errors and satisfaction (Nielsen, 1994).

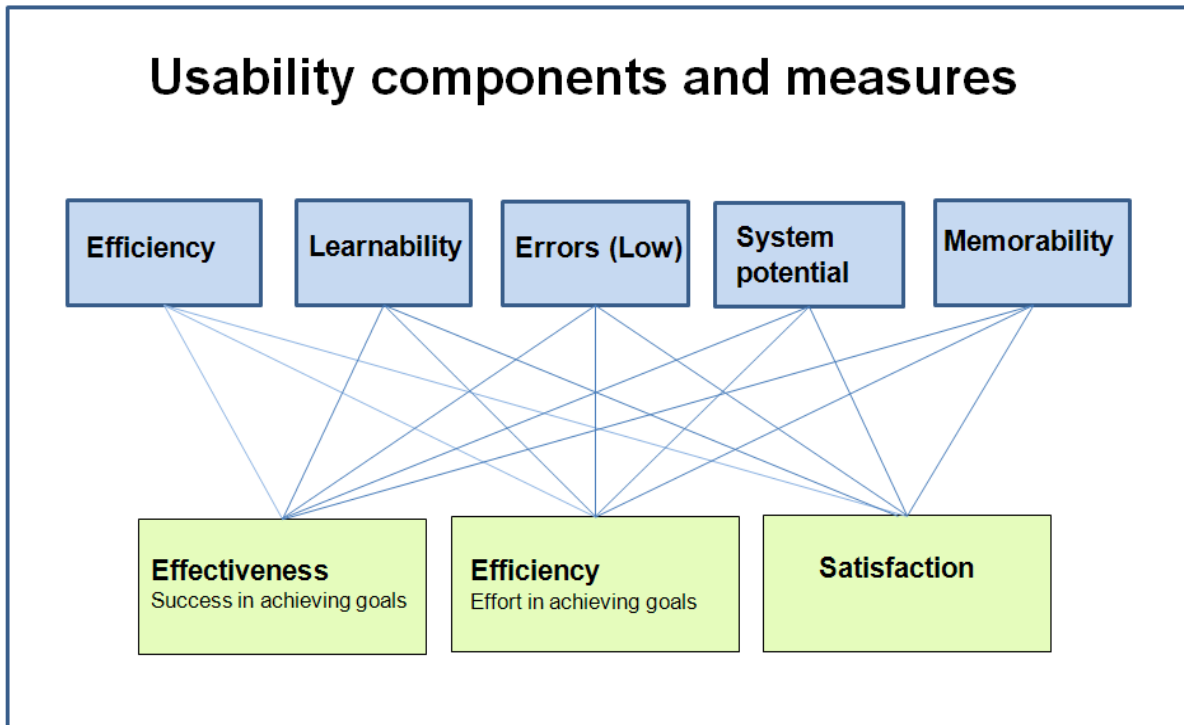


Figure 2.1 Usability components and measures (Adapted from Hopkins, 2011)

2.2.3 Usability and user-experience (UX)

There is an on-going debate among researchers and practitioners on user experience (UX) regarding what it entails and how it should be defined. UX is a person's perceptions and responses that result from the use or anticipated use of a product, system or service (ISO, 2008). It is seen as focussing on the emotions, sensations and value that the user derives from interacting with the system (Law, Roto, Hassenzahl, Vermeeren & Kort, 2009). These perceptions and responses can be equated to the satisfaction aspect of usability. Satisfaction in usability is defined as freedom from discomfort, and positive attitudes that the user has towards the use of the system, and is similar to the person's "perceptions and responses" as stated in the definition of user experience (UX) (Petrie & Bevan, 2009).

2.2.4 How usability is evaluated

Usability evaluation methods gather information about the usability of a system, whether or not a system is usable and the extent to which it is usable in order to assess or improve its interface. In the Web environment, usability evaluation methods gather information on Web

design aspects. Evaluation methods that measure a system's usability can be considered to be formative or summative based on when evaluation occurs in the development lifecycle (Blecken, Bruggermann & Marx, 2010). They can also be classified into analytical methods and empirical usability evaluation methods (Blecken et al., 2010). Three analytical methods of usability evaluation; model based evaluation, the keystroke level model (KLM) and heuristic evaluation, are outlined in section 2.2.4.1. Section 2.2.4.2 describes the empirical usability evaluation method, usability testing, which was selected for this study.

2.2.4.1 Analytical usability methods

(a) Model based evaluation methods: These involve modelling of user performance. The way in which users would use the system is modelled in order to provide predicted usability measures through calculation or simulation. Examples of model-based evaluation methods are the GOMS and Key stroke level model.

- i. GOMS stands for Goals, Operators, Methods and Selection rules (Trewin, John, Richards, Swart, Brezin, Bellamy & Thomas, 2010). The specified goals are accomplished through operators or cognitive processes and physical actions such as a mouse click, which occur within a measurable time unit. The collection of operators, and sequence, that a user would perform in order to accomplish the task are the methods. The selection rules are used for a given stage of the task to determine the method to be selected. The GOMS model is used to describe procedures that a user should perform in order to execute a specific task (Kieras, 2008).
- ii. The keystroke level model (KLM): The keystroke level model is an adaptation of the GOMS model and predicts the time required to execute routine tasks by counting the number and duration of keystrokes (Trewin et al., 2010). It has three theoretical assumptions. The first is that human behaviour can be approximated by a sequence of pre-established keystroke-level primitive operators. Examples of these are: K to press a key or button; P to point with a mouse to a target on a display and H to home hands on the keyboard or other device. Other pre-established keystrokes are D to draw a line segment on a grid; M to mentally prepare to do an action or a closely related series of primitive actions; and R to represent the system-response time during which the user has to wait for the system. The second assumption is

that each cognitive and motor operator has a duration independent of how the user or the system got into the current state, that is, independent of the history of operators as explained in the GOMS model. The third assumption is that the total time for a skilled user to execute a task is the sum of the operators (Trewin et al., 2010). Consequently, the time that an expert user would take to perform different tasks can be predicted.

(b) Heuristics evaluation: Heuristic evaluation is a usability inspection method in which a set of evaluators, experts, test the system and produce lists of usability problems of a user interface and note deviations from accepted usability principles. These usability principles or heuristics describe high-level behaviours that applications should have, and provide a flexible and relatively inexpensive way for experts to assess the interface and the extent to which it conforms to the heuristics (Nielsen & Phillips, 1993). The user interface is examined by the experts to determine where it violates the heuristics, and from this usability gaps are identified. These could, for example, relate to the button labels, screen organization, error messages, inconsistent workflow and lack of warning messages. The major objective of heuristic evaluation is to find any problems related with the design of user interfaces. Heuristic evaluation is the most widely-used usability evaluation method (Ssemugabi & De Villiers, 2010). It, however, involves expert evaluators, and in practice, designers cannot really tell how good or bad their interface is without getting the targeted users to use it (Karoulis & Pombortsis, 2003).

2.2.4.2 Empirical usability evaluation method – Usability testing

This is the process of collecting empirical data during which representative users are observed as they interact with the system to carry out tasks that are typical for the system usage (Rubin & Chisnell, 2008). Usability tests enable the precise errors to be identified and described. It is however important to use usability testing together with other techniques, for example through triangulation of data collected in usability testing with eye tracking data. The following considerations and basic activities adapted from Cooper, Reimann and Cronin (2012), and Pretorius and Van Biljon (2010) are made when conducting and interpreting usability tests:

1. Test early enough to allow adjustments in the design and implementation, but ensure that this is done when enough design has been done for meaningful testing.
2. Brief participants at the beginning of the session about tasks and how recordings will be done, for example, state if participants will be video recorded.
3. Obtain written consent for participation.
4. Use appropriate tasks to test relevant aspects of the user experience.
5. Define tasks to be performed by the participants, and where possible use the “Think Aloud” technique.
6. Ensure direct interaction between participants and the system.
7. Moderate usability testing sessions and as far as possible reduce bias.
8. Note identified usability problems.
9. Focus on the behaviour of participants and establish the rationale for their behaviour.
10. Debrief participants after the usability test.

Techniques that are used together with usability testing include video feedback, log files, think aloud and questionnaires as described in Table 2.1.

**Table 2.1: Techniques used together with usability testing
(Adapted from Blecken et al., 2010)**

Technique	Description
Video feedback	<ul style="list-style-type: none"> • User and screen filmed while user performs test tasks. • Video recordings are analysed to compile usability data • Provides the opportunity to thoroughly analyse occurring problems, however it requires a lot of time
Log files	<ul style="list-style-type: none"> • Logs exact timing and sequence of events, which can later be reproduced • Documents all the user’s actions as they operate the system
Thinking aloud	<ul style="list-style-type: none"> • User verbalizes cognitions as test tasks are carried out • May be stressful for some participants and increase time to carry out the tasks • Requires an experienced investigator to conduct the usability test and interact with the test users appropriately
Questionnaires	<p>Provide the participant’s judgment of aspects of the system. Items in a questionnaire may include:</p> <ul style="list-style-type: none"> - Questions with rated scales - Multiple choice questions - Open ended questions <p>Examples of standardised usability questionnaires:</p> <ul style="list-style-type: none"> - Software Usability Measurement Inventory (SUMI) (Kirakowski & Corbett, 1993) - Software Usability Scale (SUS) (Brooke, 1996) - Questionnaire for User interface Satisfaction (QUIS) (Chin, Diehl & Norman, 1988)

Eye tracking, discussed in section 2.2.7, is also becoming a standard technique used in usability evaluation and will be used in this research together with usability testing. Various other usability evaluation methods exist including cognitive design walkthrough, standard reviews and direct field observations (Holzinger, 2005).

Sections 2.2.4.1 and 2.2.4.2 gave examples of usability evaluation methods. Although usability is an intrinsic characteristic of interactive digital system measurable through methods that HCI researchers and Interaction design professionals have developed (Cockton, 2013), the complexity of evaluating e-Learning usability is that an e-Learning application should consider both its usability and its didactic effectiveness (Ardito et al., 2006). Evaluating pedagogical issues and didactic effectiveness would require collaboration with education specialists and learning experts. This is outside the scope of this study.

2.2.5 Usability problems

Usability problems are the aspects of a system that make a user feel frustrated, slow them down or fit badly with their preferred ways of working (Hertzum & Jacobsen, 2010). Nielsen (1994) distinguishes between usability problems and utility problems, where the former refers to problems concerning how the system is to be operated, and the later which he regards as problems concerning what the system can do. A set of criteria defining what constitutes a usability problem can guard against evaluation studies ending up reporting any problem as a usability problem. Precise operational definitions of core concepts such as usability problems make studies more reliable (Hertzum et al., 2010). The same observation may be reported differently by different observers because of differences in their understanding of what they are looking for. However, a shared understanding of what constitutes a usability problem may cause certain types of problems to be missed. The development of criteria for determining what constitutes a usability problem is not easy and is dependent on:

- the system being evaluated,
- task(s) used in the evaluation, and
- the aim of the evaluation.

No matter how unambiguously criteria can be defined for determining usability problems, when these criteria are applied there would still be some subjective judgment to be made (Hertzum et al., 2010). However, determining usability problems is critical in order to provide designers with feedback for enhancing the system.

2.2.6 Usability problems in LMSs

Research on usability of LMSs has identified different types of usability problems. Operational usability problems indicate whether the objective was achieved or not achieved (Freire, Arezes & Campos, 2012). The following are the common usability problems found in the analysis of interfaces of LMSs (De Kock, Van Biljon & Pretorius, 2009; Freire et al., 2012; Ssemugabi & De Villiers, 2007):

1. **Interface problems:** Problems that relate to the visual and pictorial language of interfaces, also known as verbal pictorial language (Freire et al., 2012). They include problems resulting from the use of terms, expressions and images that create doubt about procedures and cause cognitive overload, resulting in dialog problems between the user and the system.
2. **Browsing problems:** Browsing problems occur when the structure of the system is presented in an inconsistent manner, resulting in the user taking unnecessary paths (Tullis & Albert, 2008).
3. **Content problems:** These problems are associated with the way in which information is presented to users. If information is presented in a confusing way which does not, for example, follow the sequence of activities which have been described, this can cause content problems. This can in turn create a usability problem (Freire et al., 2012).
4. **Interaction problems:** The LMS should present ways for users to interact, for example, through discussion forums, in a manner that would be motivating and encouraging for users to exchange information (Freire et al., 2012).
5. **Other usability problems related to the general human factors principles:** The general human factors principles of compatibility, consistency, feedback, error management and satisfaction are just as important in the design of interfaces in e-Learning systems as in other interactive systems. It can however be noted that with e-Learning, cultural and sociological factors can become even more important as they affect the designer

of the interface as well as the user of the system. Human factors principles and user centred design thus become even more important.

2.2.7 Eye tracking

Eye tracking is a technique by which an individual's eye movements are measured so that at any given time the researcher knows where the person is looking at on the user interface and can see the sequence in which the eyes shift from one location to another (Poole & Ball, 2006). Eye tracking necessitates special equipment with which the user's eyes and views are tracked and recorded (Nielsen & Pernice, 2009). In this research, Tobii eye tracking equipment and the software called Tobii studio were used to record users' eye movements on the computer screen. Usability data obtained through eye tracking include visualisations of eye-movement, tracked through fixations, saccades and scan paths and depicted as heat maps (*discussed in section 2.2.7.1*) and gaze plots (*discussed in section 2.2.7.2*). Eye tracking shows what areas of a Webpage are receiving a user's attention and what areas that are being ignored (Nielsen et al., 2009).

Eye tracking visualisation data such as gaze plots and heat maps is often triangulated with usability testing data (De Kock et al., 2009). Usability testing assesses the extent to which users can use a software product quickly and easily to accomplish the required tasks (Calitz, Pretorius & Van Greunen, 2005). Eye movement analysis provides unbiased data, and detailed information of the participants' perception and comprehension. It provides highly relevant data, otherwise not collectable by conventional usability evaluation methods (Schiessl et al., 2003). The usefulness of usability data obtained through eye tracking is based on the eye-mind hypothesis, a principle that states that what a person is looking at indicates what they are currently thinking about or attending to (Nielsen et al., 2009). Analysis of usability data obtained through eye tracking can therefore contribute to an understanding of cognitive processes and the user's data interpretation strategies (De Kock et al., 2009).

Drawbacks of eye tracking that have been cited include high financial costs and the amount of time and resources required to analyse the data collected, which can be immense (Schiessl et al., 2003). The use of an eye tracker requires a knowledgeable,

experienced investigator to use the tool, and correctly conduct usability testing. Correct calibration of the eye tracker for each participant at the start of the usability sessions is an important factor as it ensures that correct data is collected. The expertise of the researcher can also influence the quality of the data collected through eye tracking (Schiessl et al., 2003). For example if calibration is not done accurately at the start of the eye tracking session, for each participant, collected data can be inaccurate. The segments that are defined in order to produce the heat maps and scan paths also need to be defined with a degree of precision. If segments are poorly defined, comparisons and interpretation may be difficult. In spite of this, eye tracking provides concise, summarized, visual evidence of usability problems when testing special groups of users (Cardoso, 2005), hence its relevance in this study.

2.2.7.1 Heat maps

A heat map is a graphical representation of data where the accumulated focusing time is represented in different colours (Chen, Yamada and Takama, 2010). In Human-Computer Interaction (HCI) and in the user experience field, heat maps are used to represent various types of data, such as usage (number of clicks or key presses), and visual attention (Bojko, 2009). In this study only “attention heat maps” are used to indicate visual attention on the user interface. The heat map is representative of gaze data where areas of an image with high concentrations of fixations are coloured red, while lower concentrations appear in “cooler” colours such as green, yellow and orange (Wooding, 2002). The colours green, yellow, orange and red are used in this study to indicate the areas on the Webpage where the most attention was focussed. Green is at the lower end, and is used to represent less focus, followed by yellow and then orange. Red is at the highest end, representing the areas that participants focussed on the most.

2.2.7.2 Gaze plots

A gaze plot shows the participant’s scan path and the fixations recorded while the user completes a task (De Kock et al., 2009). Fixation in context, refers to the focusing of the eye on a user interface design feature such as a menu item, and occurs when the eye rests on an object on the webpage (Nielsen et al., 2009). Saccades are the eye’s rapid movement from one fixation to the next. An increase in the number of a user’s fixations on

the item may indicate difficulty in extracting information, or some frustration of the interaction with the user interface (Tzanidou, 2003). Fixations provide information about which items the user looked at and which ones he did not look at, and can indicate the user's productivity or confusion (Nielsen et al., 2009).

2.2.8 Iterative development of user-interfaces

User interfaces are an integral part of systems development and their design should be part of any software analysis and design methodology (Singh & Kotze, 2003). As shown in Figure 2.2, iterative development of user interfaces involves design refinement based on evaluation through user testing and other evaluation methods. Interface designers design the system, and note problems experienced by users during user testing and improve the design based on the feedback.

Evaluation of the system, as depicted in Figure 2.2, is closely related to the design and development of a system.

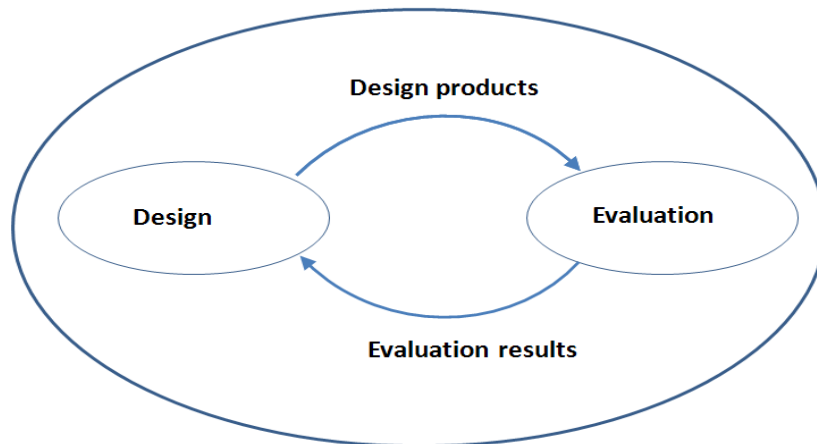


Figure 2.2: Interplay between user interface design and evaluation as key activities in software development (Puhretmair and Miesenberger, 2005)

Evaluation is carried out during different phases of the system development life cycle. Formative evaluation of the system occurs during system development and provides feedback into the design for refinement. Summative evaluation takes place at the end of system development, and can also be used to assess the functionality of an existing

system (Rogers, Sharp & Preece, 2011). Feedback information gathered during evaluation is used to improve user interface design. This process may sometimes become complicated. If evaluation occurs too late in the development process or takes too long, the feedback has limited effect on the design process. This is compounded by the fact that designers deal with complex software development issues including providing access to diverse users (Shneiderman, 2003).

2.2.9 User-centred design

User-centred design is an approach to design that bases the design process on information about the people who will use the product, and focuses on users throughout the planning, design and development of the system (Usability Professional’s association, 2012). It involves establishing the users’ needs and requirements, developing alternative designs for those requirements, after which interactive versions of these designs are then built. Consideration of who the users are and what the system is supposed to achieve is integral to the process of user centred design as shown in Figure 2.3.

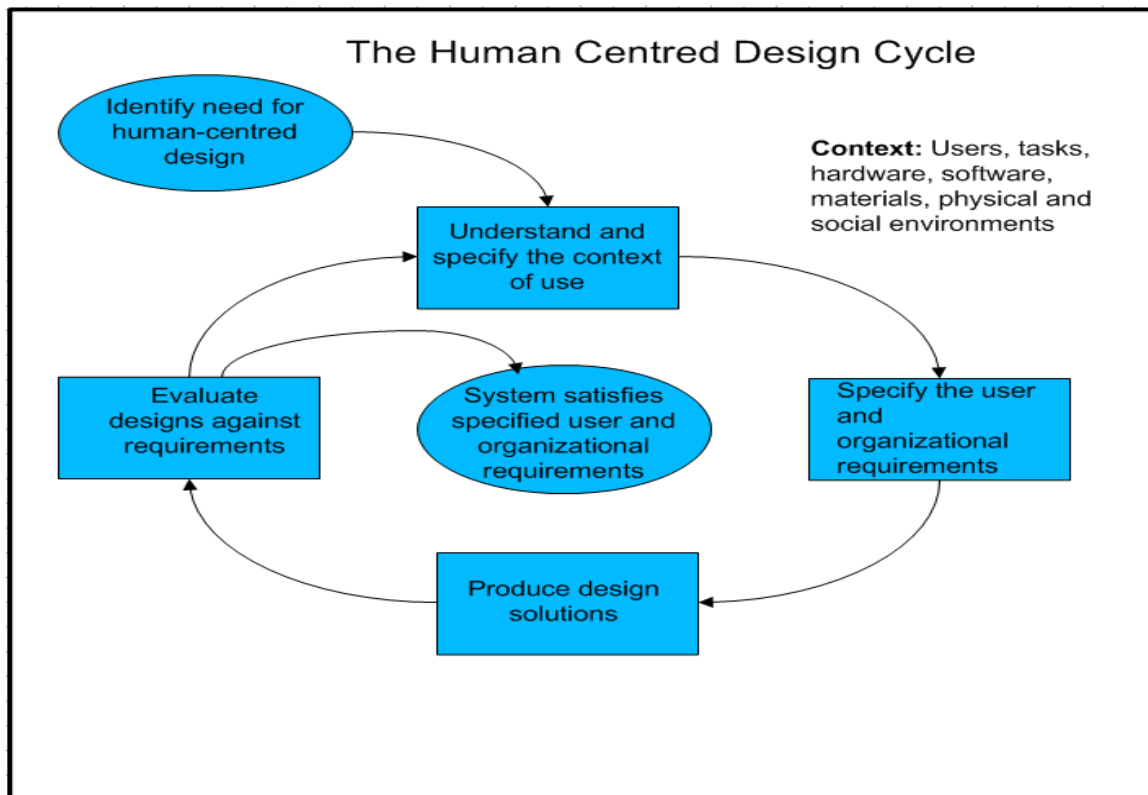


Figure 2.3: The human centered design cycle (Hopkins, 2011; ISO13407, 1999)

Any system designed for people should be easy to use, learn, remember and helpful to users (Nielsen, 2004). Designers striving for usability follow the three design principles:

1. Early focus on users and tasks,
2. Empirical measurement, and
3. Iterative design.

A consideration that needs to be made during systems design is to determine who the users are. It is important that designers should understand the users' general background, and the context in which they use the system. User-centered design places the user at the center of the design process (Hopkins, 2011). Figure 2.4 presents an iterative approach to user-centred design.

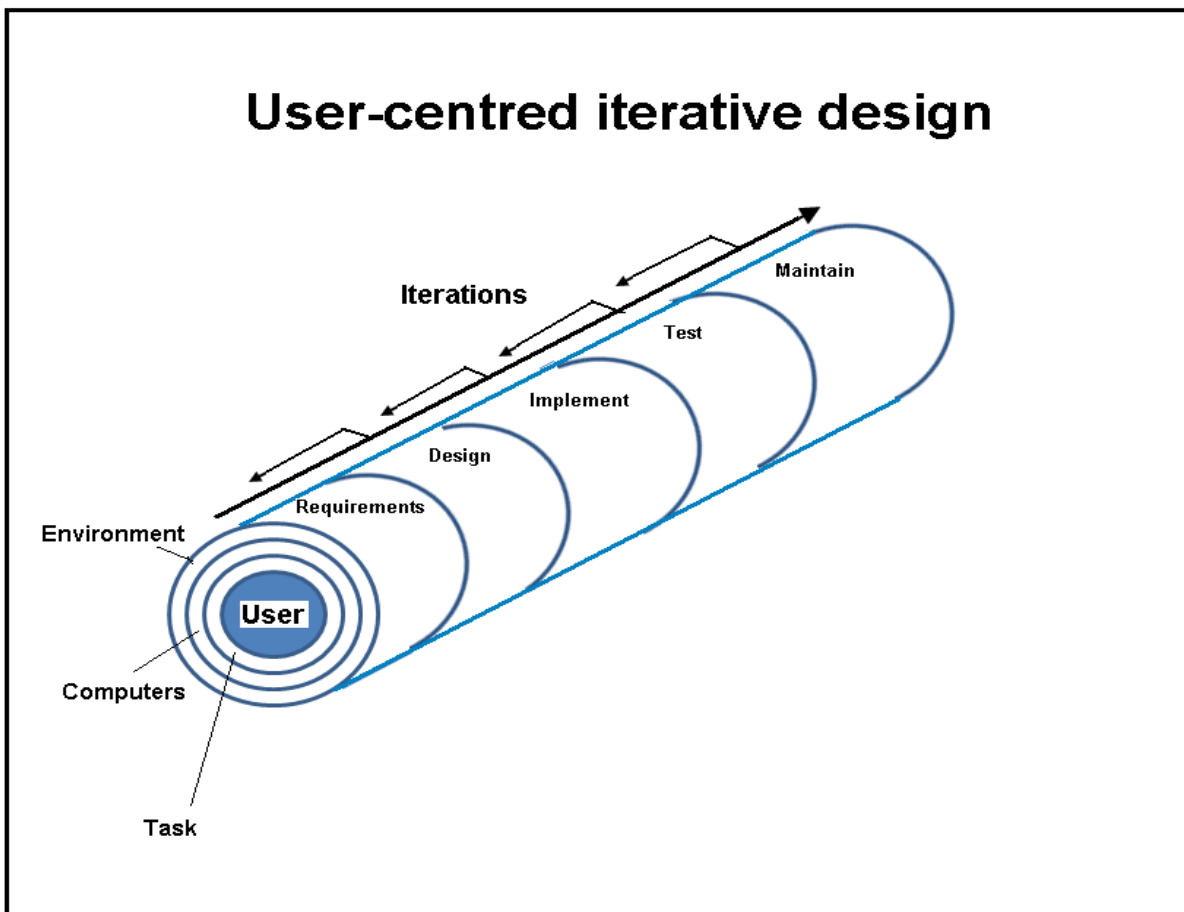


Figure 2.4: User-centred iterative design (Hopkins, 2011)

2.2.10 Interactive interface design for experts and non-experts

There are significant differences between the cognitive activity levels of experts and non-experts (Law, Atkins, Kirkpatrick & Lomax, 2004). This difference in cognitive activity can be demonstrated through eye tracking (Dix et al., 2004). It has been shown that experts operate at higher cognitive levels, relying more on knowledge from the judgment and wisdom categories whereas novice users rely more on declarative knowledge (Prumper et al., 1991; Popovic, 2007). Popovic (2007) suggests that all interactive interface design should facilitate transition from novice to expert user.

2.2.11 Comparative analysis between users of interactive interfaces

Popovic (2007) investigated the features that show what kind of processes, representations, strategies, or knowledge organisations occur during the users' interaction with the technological device. In his research on the differences and similarities between novice and expert users of interface artefacts, he used protocol analysis to identify users' cognitive categories, their knowledge categories, and the way in which they represent knowledge. He took the premise that domain specific knowledge plays a significant role in distinguishing a user who is a novice from an expert user. As a result of this he identified the way in which different users interacted with technologically-interactive devices.

Popovic used Think Aloud (TA) protocols, audio and video recordings data that he analysed, interpreted and transcribed what users verbalised into one of thirteen cognitive categories which he identified. These cognitive categories include Error, Search and Uncertainty that are relatively easy to understand. For example, for the cognitive category Error, while an expert user would exhibit characteristics of problem awareness, a novice shows uncertainty and "trial and error". In the Search cognitive category, an expert user shows superior memory recall versus weak memory recall of a novice user. Popovic's categorization of the cognitive categories acknowledges that experts' and novices' operations of interactive artefacts depend on their knowledge in a particular domain of expertise.

Section 2.3 deliberates usability of Learning Management Systems. The ODL environment is elucidated and the e-Skills proficiency levels of the users in an ODL environment are explained and related to the usability problems that are commonly encountered by users of learning management systems.

2.3 Usability of Learning Management Systems

2.3.1 Learning Management Systems

Learning management systems are systems capable of storing, managing or modifying educational content, by interaction between the participants in the system, through their authorization to insert, alter or delete data (Freire, Arezes, & Campos, 2012). LMSs such as Moodle, Blackboard and Sakai, offer basic tools to store educational content. These include virtual shelves for text and presentations to be deposited, discussion forums, notice boards, wikis, blogs and emails (Freirie et al., 2012.). Students can access learning material and communicate with their instructors and peers online. Some LMSs such as Moodle, allow their data management structure to be modified by the users according to their needs.

LMSs include pedagogic functions such as providing functionality for (Padayachee, Kotze & Van der Merwe, 2010):

- Communication between students and instructors, and among students
- Creating learning content and delivering it to students
- Managing and maintaining student records
- Organizing students, for example, grouping students for collaborative assignments
- Providing discussion forums for students
- Making announcements
- Providing course material
- Sending and receiving e-mails
- Exchanging files

Another functionality that LMSs have is to provide statistics about courses, and about the

students' data, and to provide a way in which students' progress can be tracked. One important feature of an LMS is to provide appropriate response times, so that when users perform functions such as uploading and downloading files, acceptable levels of performance are achieved even during times when large numbers of students may be logged onto the system. The LMS also provides security mechanisms to ensure the confidentiality of information. This includes, providing secure access through the use of usernames and passwords for identification and authentication of instructors and students. It also ensures confidentiality of information. Padayachee et al. (2010) identified the following criteria (Table 2.2) in relation to usability of LMSs according to the ISO/IEC 9126 model:

**Table 2.2: Criteria for evaluating usability of LMSs
(Sources: ISO/IEC 9126; Padayachee et al., 2010)**

Usability	
Understandability	<ul style="list-style-type: none"> Consistent use of terms throughout the system Consistency of layout Functions of buttons System terminology related to pedagogic tasks Consistent positioning of error messages on the screen Clear prompts for input Informing users of systems progress Match between task in interface and task as understood by the user Ease of understanding information (and documentation) provided by the system and supported by the system
Learnability	<ul style="list-style-type: none"> The level of difficulty when learning to operate the system The level of difficulty when exploring new features through trial and error The level of difficulty when remembering names of use commands The ease and straightforwardness of performing tasks The usefulness of help messages on the screen The clarity of supplemental reference materials (online help, onscreen messages and documentation)
Operability	<ul style="list-style-type: none"> The level of ease with which tasks can be performed such as uploading resources, organising students into groups The clarity with which information is organised The logic and clarity in which sequence of screens is presented The level of ease when correcting errors Effectiveness of help systems in use Ease of finding required information
Attractiveness	<ul style="list-style-type: none"> Pleasantness of systems interface Attractiveness of systems interface

For e-Learning to be successful, understanding the needs of the students, their diversity, and applying user-centred design principles is important (Dimitrova, Sadler, Hatzipanagos

& Murphy, 2003). The diversity of the students can be in terms of their ethnicity, gender, age, religion, disability, language, culture, and education background. Students differ in their prior domain knowledge, their pre-determined learning style, individual approach to learning, personal motivation, expectations, social contexts of education as well as the student's personal life style (Dimitrova et al., 2003).

2.3.2 Open Distance Learning (ODL)

In today's digital age, e-Learning has become more and more important, especially in the context of teaching at universities. As blended learning techniques become more widely employed, learners should not only have continuous access to their learning material, but also be able to collaborate with both teachers and other learners remotely. As shown in Table 2.3 conventional content management systems are replaced by learning management systems which offer a broader range of functions (Padayachee et al., 2010).

Effective use of technology enhances teaching and learning. Institutions of learning, including Unisa the ODL institution where the study was carried out, have put in place ICT enhanced teaching and learning strategies aimed at optimizing the affordances of technology in teaching and learning. One of the objectives of such strategies is to equip students with generic ICT skills and for lifelong learning. Students should be able to make optimal and appropriate use of technologies for conceptual understanding, personal development and professional competence (2015 Unisa ICT strategy, 2011). Students are encouraged to use technology in innovative and effective ways for learning and knowledge construction.

The pragmatic philosophy adopted in this study supports a constructivist approach for e-Learning systems, regarding technology as a tool to enhance learning. A learner centric environment that supports diversity is purported. A constructivist e-Learning system enables students to engage in interactive communication activities that they can self-direct to allow for individual knowledge construction (Liaw, 2005). Research also shows that the constructivist learning theory is relevant for e-Learning (Hung & Nichani, 2001; Koohang & Harman, 2005).

2.3.2.1 Learning in the digital age

Constructivists view learning as a personal, subjective interpretation of the world which occurs as the individual interacts with the environment (Tam, 2000). It is an active process during which knowledge is constructed. Conceptual growth occurs as internal representations of the individual are developed. Previous knowledge and experience form a base for this development (Carlie, Jordan & Stack, 2004). This means that learning should be learner-centred, encourage active engagement and discovery by the student, and should take the learner's perspectives and values into consideration. Consequently, diversity among learners should be acknowledged.

There are various approaches to teaching and learning and one such approach is augmented learning which refers to the use of technology to extend paper-based courses. There is usually a progression from technology augmentation to online teaching and learning. This is done by using audio CDs, multimedia DVDs, audio and video conferencing, satellite broadcasting or the basic functionalities of the LMS such as resource uploading and discussion forums (2015 Unisa ICT strategy, 2011). Augmentation may be extended to include use of externally hosted Web 2.0 tools such as Facebook (<https://www.facebook.com/>) and Blogger (www.blogger.com). In an ODL context, blended learning refers to using technology to replace components of existing paper-based distance education programs with technology. These can include using more advanced tools of the LMS such as podcasting and e-portfolios, or it can refer to face-to-face interaction with students both physically and via bidirectional synchronous technology such as video conferencing and Internet telephony using voice over Internet Protocol, VoIP (Unisa ODL policy, 2008).

In pure online teaching and learning, technology entirely replaces paper-based and face-to-face education. The capability for fully online programs can be attained through some LMSs, using e-mail and associated Web 2.0 technologies. However, blended learning is often adopted, the guiding principle being the appropriateness for the student profile (2015 Unisa ICT strategy, 2011). ICT enhanced teaching and learning strategies advocate for research which is systemic, strategic and which provide evidence into the impact of a

range of technologies on the effectiveness of teaching and learning. There is a need to explore effective ways of teaching and learning with new technologies (2015 Unisa ICT strategy, 2011). The evaluation criteria for the ICT enhanced teaching and learning strategy include student satisfaction and involvement, national and international recognition of the effective, innovative and appropriate use of technologies in teaching and learning. The numbers and success of students that make full use of appropriate technology, and the extent to which these technologies are found to contribute to employability and lifelong learning of students, indicate the effect of ICT enhanced teaching and learning.

2.4 E–Skills Competence

There is currently no universally adopted definition of e-Skills (Merkofer & Murphy, 2009; Department of Communication, 2010). In this study the definition of e-Skills used is that adopted by the South African E-Skills Institute which defines e-Skills as “the ability to use and develop ICTs within the context of an emerging South African Information Society and global Knowledge Economy, and associated competencies that enable individuals to actively participate in a world in which ICT is a requirement for advancement in government, business, education and society in general” (Department of Communication, 2010, p2). The terms ICT skills and e-Skills can be used interchangeably (European e-Skills Forum, 2004; Presidential National Commission on Information Society and Development (PIAC on ISAD), 2011). Similarly, the terms ICT skills and e-Skills are used interchangeably in this study.

The “e-Skills competence” of the user is the ability that the user demonstrates in applying their knowledge, skills and attitudes for achieving observable results when using ICT applications (European Commission, 2012). E-Skills are defined in terms of the ICT competencies, that is, ICT user skills needed for modern life; ICT skills in the workplace and technical or practitioner skills for the ICT specialist (European e-Skills Forum, 2004; PIAC on ISAD, 2011). In discussing the e-Skills landscape in South Africa, Merkofer and Murphy (2009) note that a standardised framework for defining and describing e-Skills does not exist.

Pretorius and Van Biljon (2010) categorise e-Skills competencies as novice, competent and proficient. E-Skills are also categorised using the End User e-Skills framework, which is used for categorizing end user e-Skills by industry, certifying organisations, regulatory authorities and individuals (European Committee for standardisation, 2010). In this study the different e-Skill levels of the users are classified according to their “Digital Proficiency”, which are the skills and knowledge that an individual would demonstrate at the varying levels of the Digital Proficiency Framework shown in Figure 2.5 (ECDL Foundation, 2011).

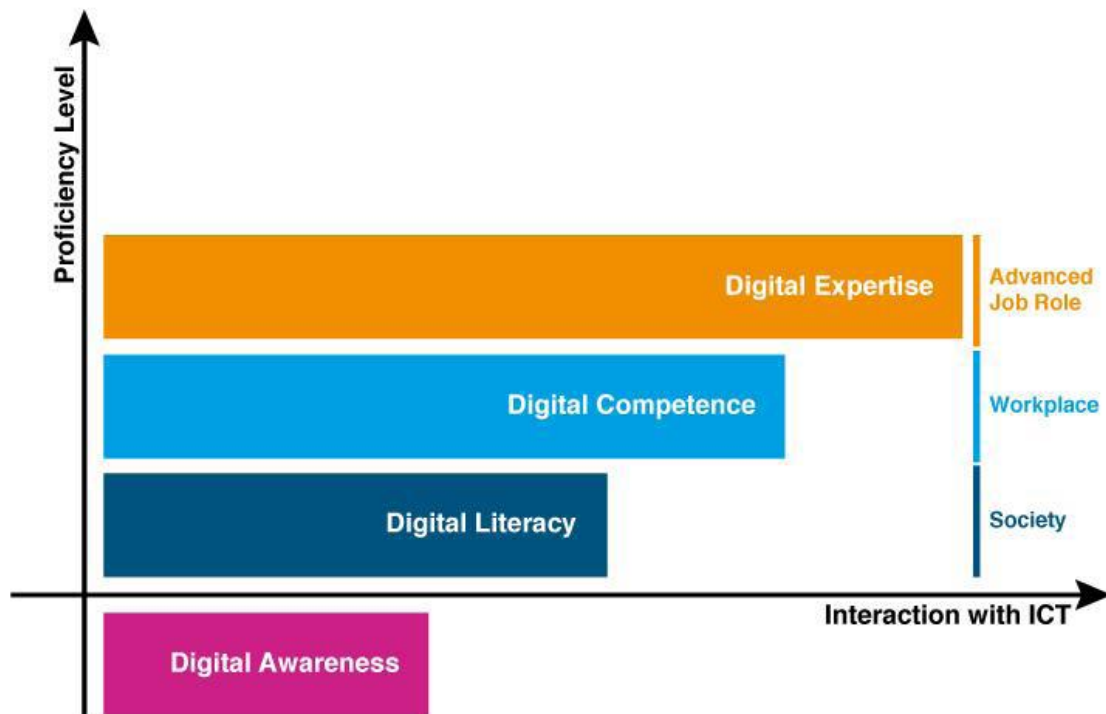


Figure 2.5: Levels of Digital Proficiency (ECDL Foundation, 2011)

The Digital Proficiency Framework has four levels:

1. Digital Awareness: “Digital Awareness” is a foundational level. It allows an individual to build up their skill level as they start to interact with ICT, and increase to a level of “Digital Literacy”.
2. Digital Literacy: At the “Digital Literacy” level the individual possesses essential ICT skills and knowledge to effectively use some common applications. These skills and knowledge enable the user to carry out common tasks that arise in the workplace or society. The skills that characterise this level typically include using the Internet in an

effective and secure way. These skills are essential and enable the user to develop more specialised skills and knowledge.

3. Digital Competence: At the “Digital Competence” level an individual possesses the required skills and knowledge specific for the workplace, and can operate a range of applications effectively.
4. Digital Expertise: The “Digital Expertise” level is when the individual possesses a high level of ICT skills and knowledge in the use of specific applications and tools, over and above the levels commonly required. At this level the user can exploit the potential of ICT fully. As a result of the skills and knowledge the individual possesses, the individual is regarded as an expert in the use of a particular application.

Table 2.3 is a summary of the Digital Proficiency Framework and shows characteristics of the digital proficiency levels as described by the ECDL Foundation (ECDL Foundation, 2011).

Table 2.3: Digital Proficiency Framework: Summarised characteristics of digital proficiency levels (Adapted from ECDL Foundation, 2011)

Level of digital proficiency	Operating Context	Characterised by	Applications and knowledge level
Digital Awareness	Digital inactivity	Individual starting to interact with ICT	Lacks essential ICT skills such as – concepts of ICT, using the computer and managing files
Digital Literacy	Society	Individual possesses essential ICT skills to actively participate in society. Essential ICT skills herein include: - Basic ICT concepts (Knows what is a computer, Internet, e-mail). - manage files	Understands concepts of ICT - can use the computer - manage files - use the Web in an effective and secure way - can use e-mail
Digital Competence	Work	Individual can operate a range of applications effectively in society and in the workplace	Can operate applications such as presentations, spread sheets and Word documents
Digital Expertise	Advanced job role	Individual possesses a high level of ICT skills and can exploit the potential of ICT fully within specific advanced role, and can be regarded as an expert in the use of the particular application(s)	Individual has knowledge of specific applications and tools over and above those commonly required For example: - Knows advanced concepts of applications such as presentations, spread-sheets and Word documents. - Can export and import files between different applications such as Excel and word, understand database concepts.

2.5 Classifying e-Skills in the context of LMSs

Although there are many studies that report on usability (Popovic 2007; Pretorius et al., 2010), there are relatively few studies that relate the e-Skills competence levels of users to the usability problems experience by the users when using the system. More research on e-Skills that use methodical and valid approaches are required (Alexander et al., 2009). In higher education, ICT skills contribute to graduateness. Graduateness is defined by Higher Education Institutions (HEIs) as preparedness to enter the labour market and at the same time assume an active citizenship in society at large, and ensure future knowledge generation (Swanepoel, 2012). Besides analytical, problem solving and writing skills, as well as social awareness and responsibility skills, computer literacy is one of the recommended skills for graduateness.

2.5.1 Classifying e-Skills

ICT skills can be categorised into two groups (Miliszewska, 2008):

- i. Use of software and hardware tools: These include operating systems, word processing, spreadsheet applications, presentation software, database applications, web applications, mobile devices, hardware and software installation, principles of networks.
- ii. The responsible use of Internet services: Including e-mail, web browsing, digital authoring, electronic databases and principles of digital communication.

Miliszewska (2008) asserted that digital technology permeates every facet of the economy, and university graduates need to develop these advanced ICT skills. She observed that the rapid development of information technology and electronic communication is pervasive and nascent and graduates require ICT skills as core graduate attributes. Her research considered the skills required by university graduates to successfully participate in today's global economy. She noted that ICT skills and digital literacy, unlike information literacy, have been largely overlooked in Core Graduate Attributes (CGA).

Miliszewska (2008) considered the development of ICT skills in students in Australian universities. She pointed out that since the publication of the Nielsen report on employer satisfaction with graduate skills (Research report 99/7) most Australian universities have developed Core Graduate Attributes (CGA) policies to address the desired attributes of their graduates. She emphasized the need to develop advanced ICT skills in university graduates that will enable them to share knowledge, information and insights. She acknowledged the growing acceptance that development of graduate skills is part of the role of higher education which, as she stated, academics, education policy-makers and employers seem to agree on.

Pretorius et al. (2010) studied an ODL institution in a developing country. They noted that the Web is becoming the preferred delivery mode of learning management services such as student enrolment and assignment submission. They also concluded that in developing countries the students' ICT skills vary greatly and this influences their ability to use LMSs and therefore their learning. Their research classified participants into two categories, expert and non-expert. The non-expert category included novice and intermediate users. The classification was based on students' Web browsing skills. They used a questionnaire which captured computer experience as well as Internet use experience of the participants to rate the e-Skills proficiency of users.

This categorization identified five types of users, that is, Never used the Web; Beginner (have read pages on the Web); Novice (have entered addresses and used bookmarks); Competent (can use a search engine to find information); and Proficient (know way around and have done Web transaction like e-banking). Based on the performance of the users on tasks such as submission of assignments on the LMS, they concluded that usability is critical in LMSs and more so where the Web is the only delivery mode and students' ICT skills vary (Pretorius & Van Biljon, 2010).

The classification of e-Skills used by Miliszewska (2008) is similar to that adopted by Pretorius and Van Biljon (2010) however, Miliszewska places more emphasis on "advanced" ICT skills as core graduate skills. The context of her discussion needs to be taken into account. Miliszewska's research considers the development of ICT skills in

students in developed countries, Australian universities in particular, whereas the context of this study, like that undertaken by Pretorius and his colleagues, is in the context of an ODL institution in a developing country where the ICT skills of students entering university are significantly diverse.

While it may be difficult in this context to incorporate “advanced” ICT skills as CGA for students who do not have ICT as a major, there are, however, basic computer skills that students require to effectively use a LMS for learning. These include but are not limited to, the use of hardware and software tools such as operating systems, word processing as well as Internet services such as e-mail and web browsing. While consideration of resource constraints, that is, limited time and money, for advanced training should be made, universities should at least ensure that all graduates have or acquire basic ICT skills needed for effective functioning in work and society.

The e-Skills assessment tool used in this research was based on the use of software tools. These included operating systems such as Windows, word processing software such as Microsoft Word, and spreadsheet applications such as Excel, presentation software and Web applications as well as the use of the Internet services such as e-mail and Web browsing. More research should be performed to investigate support measures for first time users of the LMSs (Pretorius & Van Biljon, 2010). Means should be provided to assist first time users of LMSs so that they can get past the problems they encounter.

2.6 Conclusion

Usability, eye tracking and usability evaluation in the context of a LMS in an ODL environment have been deliberated on in this literature review. This establishes a basis for investigation of the usability problems experienced by students with varying e-Skills competence levels when using an LMS in an ODL environment. The e-Skills competencies are classified using the Digital Proficiency Framework which uses four categories: Digital Awareness, Digital Literacy, Digital Competence and Digital Expertise. Usability of a system, and the way in which it can be measured by determining its effectiveness, efficiency and satisfaction were discussed. Any system designed for human use should be

easy to use, easy to learn, easy to remember, and helpful to users. Usability evaluation systematically collects data that tells about what it is like for a particular user or user group to use a product in a particular environment, and provides information about the usability of the system in order to improve its interface design. The eye tracking technique and related visualisations, heat maps and gaze plots, were outlined and the role of eye tracking in usability evaluation was discussed. It is within this context that the relationship between the usability problems and the e-Skills competencies of students will be examined.

Chapter 3: Research Methodology and Design

3.1 Introduction

This chapter describes how the research was carried out; the methodological and design choices made in order to answer the research question, the philosophy and strategy that were chosen for the research, and the data collection approach. Section 3.2 explains the philosophical orientation of the study, which is pragmatic, and the influence of positivism and constructivism is explained. Section 3.3 outlines the research philosophy and discusses the pragmatic orientation of the study. Section 3.4 deliberates on the inductive and deductive research approaches and their relevance in the research. The case study and the rationale for selecting it as the research strategy are discussed in section 3.5. The research method and the way in which it is applied in this study are explained in section 3.6. Section 3.7 states the research proposition and the research questions.

3.2 Research methodology

The research methodology for this study is represented in Figure 3.1. This representation is based on the research process “onion” model (Saunders, Lewis & Thornhill, 2009). According to this model a research process should include a philosophy, an approach, a strategy, and a research method in addition to the time horizon and data collection methods. The research’s philosophical orientation is pragmatism and the research approach is mainly deductive. The case study has been selected as the research strategy. The mixed method, which uses both qualitative and quantitative methods for gathering, analysing and interpreting data was chosen for the research. These concepts and the rationale for their selection are further discussed in the following sections.

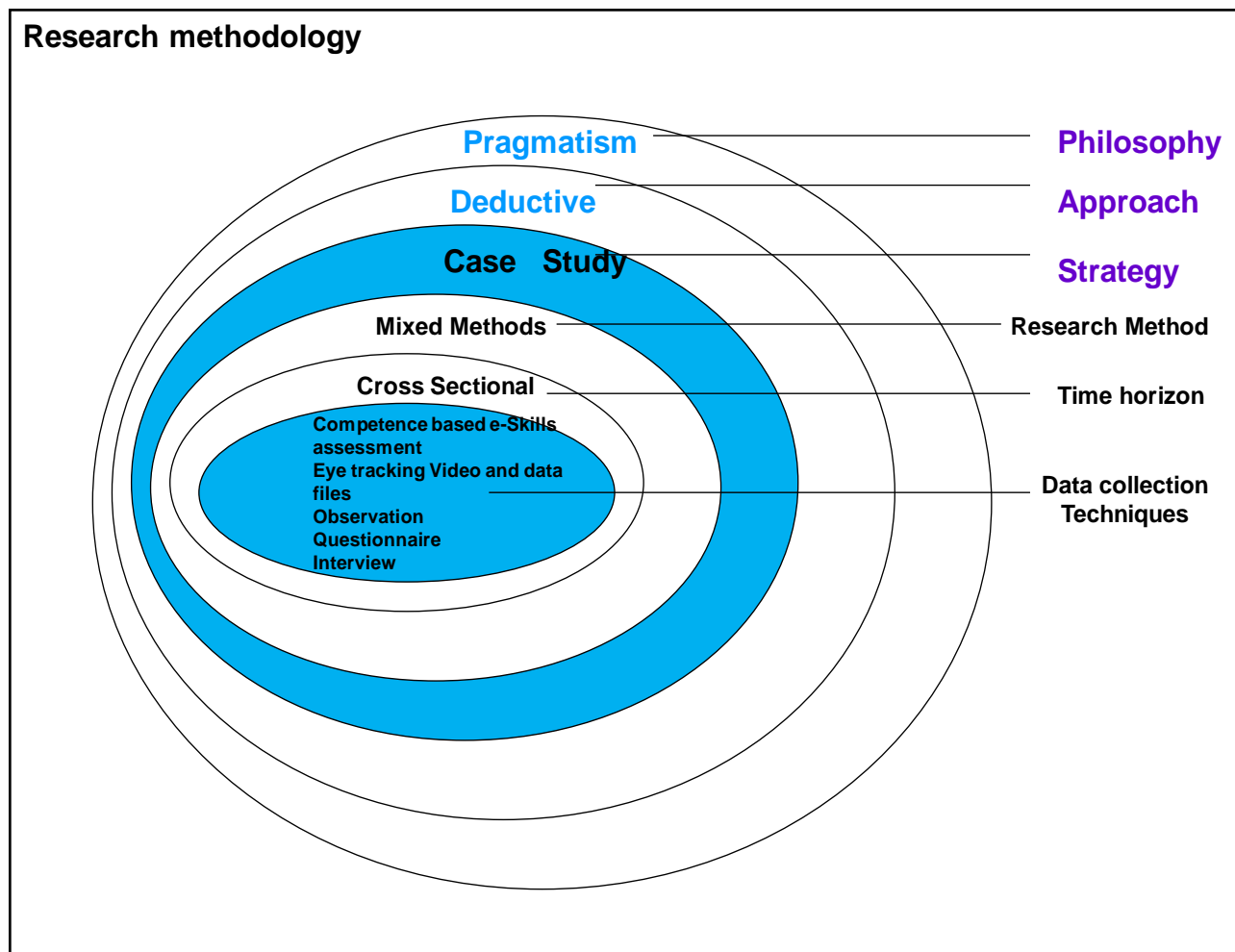


Figure 3.1: Research methodology
 (Adapted from the Research process onion by Saunders et al., 2009)

3.3 Research philosophy – pragmatic orientation

Pragmatism is the underpinning philosophy for this research. It is the philosophical orientation mostly associated with mixed methods (Bryman, 2006). Pragmatism draws from the different philosophies and is not committed to any one system of philosophy, whether positivism, constructivism or interpretivism (Cresswell, 2009; Teddlie et al., 2009). The research method used in this study is mixed method in which both quantitative and qualitative data is collected. Subsequently, both positivism and constructivism are relevant in the research. This is because quantitative researchers work within the positivist and post-positivist paradigms, while qualitatively oriented researchers subscribe to the constructivist paradigm.

Positivism involves the use of scientific methods and rigorous testing of hypothesis by means of quantitative, numerical data, and analysis while post-positivism, a revised form of positivism, is more objective and acknowledges that the researcher's values affect how they conduct the research and interpret findings (Johnson & Onwuegbuzie, 2004; Teddlie et al., 2009). Constructivists believe that the meaning of the phenomenon under investigation is constructed by the researcher(s), individually and collectively and are mainly interested in narrative data and analysis. This is why qualitatively oriented researchers subscribe to constructivism.

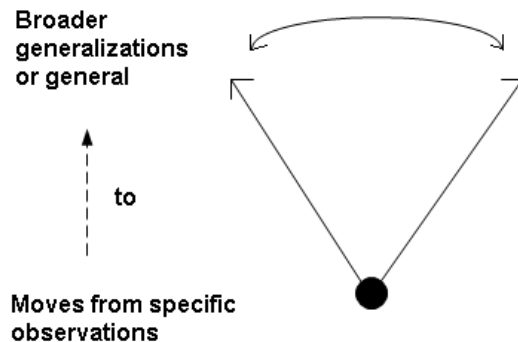
3.4 Research approach

3.4.1 Inductive and deductive reasoning

The two broad methods of reasoning used in research are the inductive and deductive approaches. Inductive reasoning moves from specific observations to broader generalizations (bottom-up) as shown in Figure 3.2, and the conclusions made involve a degree of uncertainty (Burney, 2008). Qualitative data analysis is often, though not always, inductive because it is usually used to determine emergent themes. The predominantly inductive nature of qualitative data analysis therefore involves gathering data and then using it to build theory or themes that lead to specific conclusions. Inductive data analysis argues from particular facts or data to arrive at general themes or theory. Conversely, deductive reasoning works from the more general to the more specific (top-down) as depicted in Figure 3.2, and the conclusion, which is more of a confirmation, follows from the available facts (Burney, 2008).

Quantitative data analysis is predominantly deductive in nature, and involves making research hypotheses to predict specific results. Data is then collected to test the hypothesis (Saunders et al., 2009). A hypothesis can be considered as a specialised quantitative research question wherein the researcher makes predictions about relationships between phenomena based on theory or previous research or other rationale about the relationships in advance of the actual research (Teddlie et al., 2009).

Inductive reasoning (bottom-up)



Deductive reasoning (Top-down)

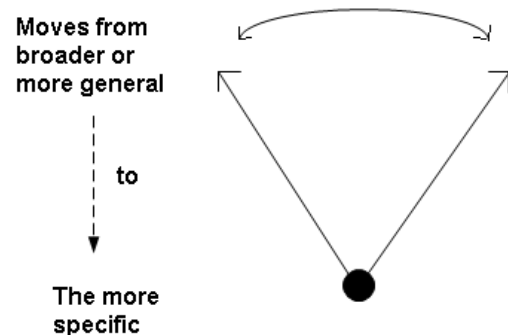


Figure 3.2: Inductive and deductive reasoning

There are instances when qualitative data analysis is deductive rather than inductive. For example, in analytic induction qualitative analysis involves a deductive component. This involves examining the data for categories and then determining the relationships among the categories, and requires examining the different cases and developing hypotheses. Thus the main characteristic of analytic induction is “negative case analysis” in which the researcher ascertains cases in the qualitative data that do not fit expected patterns. Quantitative analysis can also be inductive rather than deductive, for example in exploratory studies where it is used to generate theory or themes (Oates, 2006; Saunders et al., 2009; Teddlie et al., 2009).

3.4.2 Research approach chosen for this study

Deductive research was the main approach used in this study. The proposition tested by this study was that there is a relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students’ e-Skills competencies. In line with the pragmatic approach taken in this study which focuses on what works and advocates the use of mixed method, quantitative data was collected using the simulated online competence-based assessment of the e-Skills and during usability testing in the HCI laboratory. Qualitative data was collected through observations. The quantitative and qualitative data collected provided means to determine the relationship

between the e-Skills competence of first year university students and the usability problems they experience when using a LMS in an ODL environment.

3.5 Research strategy – case study

The case study was selected as the appropriate research strategy for this study. Case study design involves defining the case, selecting the most appropriate design and then applying theory to the design (Yin, 2009; Cresswell, 2009). It includes a set of procedures for design, data collection and analysis, as well as presenting and reporting the results. It is not just a variant of other research methods but a comprehensive research strategy that engages formal design and systematic procedures (Yin, 2009). The case study method requires a unit of analysis, the case, to be defined. A unit of analysis is the case or group of cases on which data collection focuses in order to enable the researcher to draw conclusions (Teddlie et al., 2009). The case study was chosen as a research strategy for this study because of consideration of availability of resources, in terms of time and cost, and the proximity of the regional centre.

3.5.1 The case

The case serves as a unit of analysis in a case study. A case should be an exemplary piece of research, distinctive and unique. The feature that makes the case special, distinctive, unique or revelatory should be clearly stated and there should be a compelling theoretical framework for selecting the case (Yin, 2009). In this research the case was the End User Computing module (EUC1501), and the way in which students use the LMS, myUnisa, for the module. The three aspects of the LMS that the case study focussed on were sending an e-mail with an attachment, finding a specified resource, and posting a comment on the online discussion forum. These are elaborated in section 3.10.6.

The participants were first year students studying End User Computing in the College of Science Engineering and Technology at the ODL institution, the University of South Africa. The target system is myUnisa, a LMS used by both staff and students. In the module, teaching and learning are online using a LMS, myUnisa. The objective of the EUC1501 module is to equip students with end-user computing theory and practical skills. On

successful completion, students should be able to use the computer as a learning tool and possess basic computer literacy skills.

Online activities that students perform on the LMS include submitting assignments online, finding online resources posted by the lecturers and communicating with lecturers and peers in online discussion forums. The introduction of signature modules by Unisa from 2013 means that any student starting a new undergraduate degree will have to register for and to successfully complete one compulsory online module as part of the programme requirements. Since there will be no printed study material provided to students for these signature modules, students will be required to perform these online learning activities and assessment using myUnisa.

During this study, a web-based competency assessment tool was first used to assess the students' level of digital proficiency and the participants were categorised into four digital proficiency levels as described in section 2.4, namely Digital awareness, Digital Literacy, Digital Competence and Digital Expertise. During usability testing and eye tracking sessions at the HCI laboratory direct observations and video recordings were made as students with varying e-Skills levels used the LMS to perform specific tasks.

3.5.2 The case study design

The case study design that was selected for the study is a multiple embedded design. A case study that is embedded contains more than one sub-unit of analysis, and provides a means of integrating quantitative and qualitative methods into a single research study (Scholz & Tietje, 2002; Yin 2009). The two components involved in the research are:

1. The students' e-Skills competencies: This component was obtained by segmenting the participants into different e-Skills levels using an online competence-based assessment. The participants were grouped according to their performance in the assessment into the different e-Skill digital proficiency levels.
2. Eye tracking data, fixations and heat maps: This second component was obtained as participants executed specified tasks on the LMS during usability testing and eye tracking evaluations. This was carried out by a subset of participants, representative

of the different e-Skills levels, selected from the initial group of participants. Eye tracking was used to provide visual evidence of usability problems experienced by students with varying e-Skills competencies.

3.5.3 Opposing views regarding the case study method

Although the case study approach has existed for a long time, there have been questions raised regarding theory, reliability, and validity issues (Flyvbjerg, 2011). Some of the conventional prejudices against case study, especially if the case study is done poorly, are that it should not be considered as a method but rather an exploratory phase for other research methods (Yin, 2009). It is thus regarded by some as a means by which data is collected to ascertain whether the topic is worth further investigation. There is also mistrust of the credibility of the procedures used in case study research by those who do not see it as rigorous enough (Teddlie et al., 2009). Another concern is whether the procedures adequately protect against researcher bias. For example, it may be seen as a way to confirm what the researcher set out to find in the first place. There are also perceptions that the case study's findings may not be generalized to the population and other cases (Teddlie et al., 2009). Case study, however, engages formal design and encompasses a distinct theoretical perspective and is generally accepted as a rigorous research design of its own (Yin, 2009).

3.6 Research method

3.6.1 Mixed method selected for the study

Mixed method research has emerged as an alternative to using either the qualitative or quantitative methods (Teddlie et al., 2009). Quantitative methods are techniques associated with the gathering, analysis, interpretation and presentation of numerical information (Cresswell, 2009). Quantitative research is characterised by well-articulated research questions. These are established before starting the study, and form the basis for the hypothesis. The data is then collected and statistically analysed. On the other hand, qualitative methods are techniques associated with gathering, analysing, interpreting and presenting narrative information. Classical characteristics of qualitative research are the use of emerging rather than predetermined questions to guide the research, as well as the

use of unstructured and semi-structured observations. In qualitative research there is an emphasis on fully describing the emerging scenes (Teddlie et al., 2009).

There were two components to the data collection in the study described in this dissertation. The first component of the study was the e-Skills assessment of the participants in order to ascertain their levels of digital proficiency. The second component of the study involved collection of both quantitative and qualitative data collection during usability testing at the HCI laboratory. The quantitative data that collected includes eye tracking data while qualitative data was collected using video recordings and observations. Observations constitute a highly valued aspect for case study (Yin, 2009). Questionnaires were also used. The duality of the case study, its use of qualitative and quantitative data collection methods, means that data is collected from a variety of sources. Consequently various analytic techniques, as recommended for the design of case studies can be used (Teddlie et al., 2009).

3.6.2 Rationale for usability evaluation methods used in the study

Choosing among the usability evaluation methods is often a trade-off between cost and effectiveness (Ardito et al., 2006). In this research usability testing and eye tracking were used. Usability testing was selected because it enables precise errors to be identified and described. In this study data collected during usability testing was triangulated with data collected using eye tracking. Eye tracking is one of the techniques used to identify usability problems during usability evaluation using the usability testing method. It provides concise visual evidence of usability problems and is appropriate when testing special groups of users (Cardoso, 2005).

For web-based systems eye tracking provides a record of scan patterns while the user is navigating a site, and the scan patterns are represented by a number of fixations and their connecting saccades as discussed in section 2.2.6. Fixation is the focusing of the eye on a user interface design feature, for example, a menu item. An increase in the number of a user's fixations on the item may indicate difficulty in extracting information, or some frustration of the interaction with the user interface (Tzanidou, 2003). Analysis of usability data obtained through eye tracking can contribute to an understanding of cognitive

processes, and the user’s data interpretation strategies (Pretorius et al., 2005). In spite of the cited drawbacks of eye tracking such as high financial cost, vast amount of time and resources required to analyse the collected data (Schiessl et al, 2003), eye tracking provides visual evidence of usability problems (Cardoso, 2005) and is therefore relevant in this study. In Table 3.1 the data collection techniques that were used in the research are related to the main research question, research objectives and sub-questions.

Table 3.1: Data collection techniques related to the research questions

Research Question	Research objectives	Sub questions	Data collection: Quantitative and Qualitative
What is the relationship between the e-Skills competencies of first year university students and the usability problems they experience when using a LMS in an ODL environment?	Ascertain the e-Skills competencies of first year university students	What are the e-Skills competencies of first year university students?	Quantitative: Competence-based e-Skills assessment using simulated questions Qualitative: Questionnaire
	Determine the usability problems experienced by first year university students using the LMS	What are the usability problems experienced by first year university students when using a LMS in an ODL environment?	Quantitative: Usability testing, and eye tracking of users in HCI laboratory - eye tracking data files Qualitative: Usability testing, Video recording, observations
	Ascertain how the usability problems revealed relate to the e-Skills of the students	How do the usability problems identified relate to the e-Skill levels of the users?	Quantitative: Eye tracking and video data Qualitative: Questionnaire Qualitative: Interview
	Find out what eye tracking reveals about the relationship between the usability problems and the e-Skills competencies of the users	What does eye tracking reveal about the relationship between the usability problems and the e-Skills competencies of the users?	Quantitative: Eye tracking and video data
	Examine how this information can assist e-Learning designers to develop usable LMS user interfaces that cater for varying e-Skills	How can this information assist e-Learning designers to develop usable LMS user interfaces that cater for varying e-Skill levels	

3.6.3 Data analysis approach

Mixed method analysis consists of a mixture of qualitative and quantitative procedures since well conducted mixed method research integrates statistical and thematic analysis (Cresswell & Clark, 2007; Johnson & Onwuegbuzie, 2004). The research included both

statistical and thematic analysis. Quantitative data analysis is the analysis of numerical data using techniques that include describing the phenomenon of interest, and looking for significant differences between variables (Shadish, Cook & Campbell, 2002). Qualitative data analysis analyses narrative data using inductive and iterative techniques. These include categorical strategies and contextualizing (holistic) strategies which mainly result in themes, hence qualitative data analysis is referred to as thematic analysis (Denzin & Lincoln, 2005).

Mixed method analysis provides a balance in results and interpretation when the qualitative and quantitative components are reconciled (Tashakkori & Teddlie, 2008). For this research statistical analysis was used for examining quantitative data collected during e-Skills assessment using the simulated online competence-based assessment. Thematic analysis was used for both qualitative and quantitative data collected during usability testing and eye tracking.

3.6.4 Triangulation

Triangulation involves constantly checking and rechecking the consistency of the findings from different, as well as same sources. This is done in order to establish converging lines of evidence from different data sources which makes the findings robust (Teddlie et al., 2009; Yin, 2009). When two or more independent sources all point to the same set of events, more evidence of the facts can be presented. Multiple, rather than single sources of evidence, are better. Since the case study design that has been selected for this study is a multiple embedded design, more than one sub-unit of analysis is used, which provides a means of integrating different methods into the study. In this study data collected during usability testing was triangulated with data collected using eye tracking data, observations, questionnaires and interviews.

3.7 Proposition

Using theory in the design means that a theoretical proposition indicating a simple set of relationships is made (Cresswell, 2009). My proposition was developed from the research questions: “What are the usability problems experienced by first year university students

when using an LMS in an ODL environment?” and “How are the identified usability problems related to the e-Skill levels of the users?” Ascertaining the relationship between students’ e-Skills competencies and the usability problems they experience when using an LMS in an ODL environment, is the main objective for the research. At Unisa, ODL necessitates that students use the LMS, myUnisa, for their studies.

The proposition can be stated in terms of a hypothesis as follows:

There is a relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students’ e-Skills competencies (H_1).

In case study research the researcher needs to include a rival hypothesis in addition to the adopted line of inquiry to deliberately and vigorously examine the hypothesis from a sceptical position (Yin, 2009). The null hypothesis is then:

There is no relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students’ e-Skills competencies (H_0).

This empirical inquiry will result in the hypothesis (H_1) being accepted if the null hypothesis (H_0) can be disproved, else the hypothesis (H_1) will be rejected if the null hypothesis (H_0) cannot be disproved.

3.8 Validity and reliability

The validity and reliability of the findings can be influenced by the inherent strengths and weaknesses of the strategy chosen and selection of the strategy should take this into account (Gill & Johnson, 2010). Validity refers to whether or not the stipulated cause actually produces the stipulated effect (internal validity), or the extent to which the findings can be generalized (Gill & Johnson, 2010; Teddlie et al., 2009). This can lead to generalization of the research findings to the wider population (population validity) or from the specific social context to other contexts and settings (ecological validity) (Gill & Johnson, 2010). Reliability answers the question of how consistent are the results obtained

in the research, and whether another researcher can replicate the original result with the same conditions and the same design (Teddlie et al., 2009).

The choice of pragmatism, mixed method and case study for this research included consideration of reliability and validity. Pragmatism acknowledges that the researcher's values play an important role in the interpretation of results. Cultural and personal perspectives can affect how the researcher observes, interprets and report the findings. The presence of the researcher may also affect participants' behaviour (Teddlie et al., 2003). That is why Yin (2009) suggests that field studies should be used together with other data sources. Although there is often a close, emphatic relationship between the observer and participants in quantitative techniques, they tend to be more objective (Yin, 2009). Triangulation is one of the techniques used in this study to minimize personal and methodological biases that could influence the research findings (see section 3.9).

3.8.1 Reliability and validity of the questionnaire

The questionnaire, Appendix 3, which was completed by the participants after completing the online e-Skills assessment, was tested for reliability and validity as explained in the following sections (3.8.1.1 and 3.8.1.2). The validity and reliability analysis, discussed in section 4.2.3, show that the questionnaire is valid and reliable following the tests that were performed.

3.8.1.1 Reliability

Reliability is the ability of the measure to produce the same results under similar conditions (Field & Hoyle, 2005). Reliability measures the consistency of a set of measurements of the measuring instrument. The Cronbach Alpha value is used as a measure of reliability. The value of the Cronbach alpha value should be greater than 0.8 (for good reliability); between 0.6 and 0.8 (for acceptable reliability). If the value is below 0.6, the data is considered to be unreliable.

3.8.1.2 Validity

The questionnaire also needs to have validity and measure what it is supposed to measure as discussed in section 3.8. The validity of the dimensions of the questionnaire was tested

using factor analysis. Factor analysis is used to describe variability among observed variables in terms of the factors, which are the unobserved variables.

3.9 The research process

3.9.1 The pilot study

It is advisable to conduct a pilot study with a small sample before embarking on a large empirical study (Nielsen, 2009). Pilot studies were conducted during both the e-Skills assessment and eye tracking sessions of the study. Three participants were used in each case. This provided an opportunity to ensure that the tools were properly set up and that participants understood what is expected of them. Data was collected and observations made using the planned methods. This provided information which led to some adjustments. For example, for the usability testing and eye tracking in the HCI lab, the instructions for the three tasks were initially given online and also printed. The pilot study revealed that when participants used the printed copy they took their eyes off the screen thus affecting the eye tracking. Subsequently, the instructions were retained on the screen. Minimal information was provided to the participants in print form such as the e-mail address and file name and the location that was required for one of the tasks.

3.9.2 The main study

3.9.2.1 Sampling

One of the fundamental and most important sampling decisions that the researcher needs to make is whether to use probability or non-probability sampling (McNaab, 2010). Sampling refers to the way that sample units are selected from the population. It involves selecting units of analysis in a way that maximizes the researcher's ability to answer the research questions (Tashakkori & Teddlie, 2008). Mixed methods sampling usually combines purposive and probability sampling. It also combines qualitative and quantitative techniques to answer the research questions. In probability sampling, the sample units are selected at random and all have an equal chance of being selected. Probability sampling is mainly used in quantitatively oriented studies. It involves randomly selecting a relatively large number of units from a population. Each member of the population has an equal

chance or probability of being included in a determinable way. Purposive sampling is non-probability sampling, also referred to as judgmental, selective or subjective sampling. Purposive sampling involves the researcher making decisions with regard to selecting the units that are to be studied (Teddlie et al., 2009). Purposive and probability sampling were used in this research.

The sampling process for this study was multilevel. A purposive sample of the students was made which accounts for 15% (810) of students based in the selected regional learner centre, the Thutong Learner Centre in Pretoria. This decision was based on the proximity of the facilities; the computer laboratory at Thutong Learner Centre where the e-Skills test was conducted, and the Human-Computer Interaction (HCI) laboratory where usability and eye tracking were done.

3.9.2.2 Data collection

An invitation to take part in the research was made to first year End User Computing students at Unisa. This was done through e-mail, sms as well as posters placed at Unisa's regional learner centre in Pretoria, South Africa, at which the study occurred. Three means of communication were used to send invitations to take part in the study. These were e-mail, short message services (sms), as well as posters put up around the regional learner centre where the e-Skills assessment took place. E-mail and sms messages were sent to End-User Computing students registered at the Thutong regional learner centre in Pretoria. Participants who responded by calling or registered their names at the regional learner centre were selected on a first-come, first-served basis.

There were two phases in this study.

1. In the first phase eighty six (86) participants carried out the simulated competence-based e-Skills assessment at the computer laboratory. Based on their performance in the assessment the students were categorised according to an e-Skills proficiency framework consisting of four levels: Digital Awareness, Digital Literacy, Digital Competence and Digital Expertise (section 2.4). Twenty one (21) participants representing the four levels of digital proficiency were selected from the group of eighty

six (86) students, to perform usability testing and eye tracking sessions at the HCI laboratory.

The way in which this phase was conducted is explained in section 3.9.3

2. In the second phase of the research individual sessions of usability testing and eye tracking by each of the twenty one (21) participants were carried out at the HCI laboratory.

The way in which this was conducted is explained in section 3.9.4.

3.9.3 Conducting the e-Skills assessment

The first part of the research was e-Skills assessment: Five sessions were held for the e-Skills assessment of 86 of the students who responded. The maximum amount of time allocated for the online competence-based e-Skills assessment was one hour.

The simulated competence-based e-Skills assessment tool:

The simulated competence-based e-Skills assessment tool, CompAssess, enables an organization to create and deliver customised tests over the Internet (Masterskill, 2012). It utilizes a database of questions on Microsoft Word, Powerpoint, Excel, Internet Explorer, e-mail and similar applications. All individuals need to be registered on the system before they can take a test, and are required to use a username and password. The assessment used in this study (Appendix 1), performed by each of the participants required each user to perform exercises in Microsoft Word, Powerpoint, Excel, e-mail and Internet Explorer.

The e-Skills assessment took place at a computer laboratory equipped with desktop computers. This part of the data collection was conducted at the regional learner centre which is situated close to the main campus of the University. Administering the assessment required that the venue be organised; Internet access and connectivity to the e-Skills assessment be arranged, and ensuring that students were present on the correct dates

and times. There were five, one hour sessions. Each session had, on average seventeen students.

Participants: The main criterion for participating in the study was to be a first year university student registered for End-User computing at the institution, Unisa. The institution is an open distance learning university in Africa. The eighty six (86) participants were students who responded to invitations to participate and were registered students at one of the university’s regional centres. All participants were registered for the introductory End-User computing module offered at the institution.

Eighty six (86) participants took part in the online competence-based assessment, the first phase of the research. This included 49 males and 37 females. Twenty six (26) participants were aged 20 years and below. Fifty five (55) were between 21 and 30 years. There were four participants aged between 31 and 40, and only one between 41 and 50. Table 3.2 shows this composition.

Table 3.2: Participants in online competence-based assessment

	Gender		
Age (years)	Male	Female	TOTAL
<= 20	14	12	26
21-30	34	21	55
31-40	1	3	4
41-50	0	1	1
>50	0	0	0
TOTAL	49	37	86

Each participant was assigned a workstation and logged on to the ICT skills competence-based assessment, CompAssess, with an individual username and password. Sessions were facilitated by the researcher and two laboratory assistants. During each session, participants were briefed about the study, and the type of questions used, which were simulated. Participants were also informed about the time limit of one hour. The questions

assessed computer skills such as using Microsoft Word, Excel, PowerPoint, as well as e-mail and the Internet. Tasks such as creating folders, saving files in a specific folder were also included. The detailed questions are shown in Appendix 1. There were thirty three simulated questions, weighted according to their level of difficulty. The participants answered the questions online, at the computer laboratory. The assessment tool kept a log of all assessments that were completed or attempted.

At each of the sessions, the participants' right to voluntarily choose whether to participate, and the right to withdraw at any time was explained. Consent was obtained through signing of the consent forms in Appendix 2. The consent form and questionnaires were distributed to all the participants at the same venue where the e-Skills assessment took place. These were collected at the end of each of the session.

E-Skills assessment questionnaire: The e-Skills questionnaire is included in Appendix 3. Participants were required to firstly indicate how they would rate their skills in the use of the LMS, myUnisa, and Microsoft Word, Excel, PowerPoint, as well as e-mail, Internet and their basic computer skills. This was indicated on a five point Likert scale of 1 to 5, 1 being not good at all, and 5 being very good. Demographic information was also obtained. After completion of the assessment participants used a similar scale to indicate how well they thought the system actually tested their skills with respect to the use of the applications they used. They were also asked whether the participants would recommend this type of assessment to determine e-Skills competence.

3.9.4 Conducting usability testing and eye tracking

As noted, a sub-group of the participants who took part in the e-Skills assessment who were representative of the four digital proficiency categories was selected to take part in the usability testing and eye tracking at the Human-Computer Interaction (HCI) laboratory. The HCI laboratory is equipped with Tobii eye tracking equipment. Each of the participants performed the following three tasks:

a. *Sending an e-mail with an attachment to a specified address:* The myLife e-mail system enables each student to have an e-mail address which enables them to receive

and send e-mails to lecturers and other students. It is important that each student can perform this task, particularly in an ODL environment to give students support and a sense of community.

b. *Finding a specified resource for a specified module*: Searching for information on the website is a common activity which students are required to perform online. For each module, lecturers place module related resources such as tutorial letters online. Students should be able to access this information.

c. *Posting a comment on the online discussion forum (ODF)*: The online discussion forum (ODF) is one of the major tools on myUnisa. It is available for every module site. ODFs enable students to communicate with their lecturers and fellow students, mostly asynchronously. Students can discuss topics specified by the lecturer or add their own topics. The ability to post comments enables a student to participate in the discussions. This provides an opportunity for the student to be in a learning community, an important aspect of learning. In this task students were asked to post a comment to an on-going discussion on the ODF.

Data collection during the sessions at the HCI lab included:

- a. Eye tracking: Eye tracking data files including gaze plots showing fixations, saccades, scan paths and heat maps were gathered as the participant performed the tasks.
- b. Observation: Each participant was observed by the researcher while performing the tasks.
- c. Video recording: While users performed the tasks, their actions and the user interface were video recorded.
- d. Questionnaire: the post-test questionnaire, shown in Appendix 5, was completed by each of the participants once tasks had been carried out. The user satisfaction questionnaire used a five-point Likert scale to assess participants' perception of the system's user interface; ease of use, efficiency, effectiveness, how easy it is to remember and satisfaction.
- e. Interviewing of the participants by the researcher

At the end of the session the participant was debriefed by discussing observations made during usability testing.

3.10 Data analysis

3.10.1 Qualitative data analysis

Qualitative data analysis involves analysis of narrative data. A dominant feature in qualitative data analysis is the search for themes, hence “thematic analysis”. It involves observation and interpretation based on how the researcher understands the phenomenon. Raw data is converted to partially processed data, which is then subjected to a particular analysis scheme such as inductive data analysis. Inductive data analysis leads to themes which are a result of the process of repeatedly considering the data, systematically observing for patterns and structuring explanations on these bases (Charmaz, 2006).

Categorical strategies, contextualizing strategies and qualitative data displays can be used to represent the information. Categorical strategies involve making categories in order to facilitate comparison so as to answer the research questions. Contextualizing strategies are the interpretation of narrative data in the context of the whole. Visual presentations of the themes that emerge from the categorical and contextualizing strategies form the qualitative data displays. Thematic analysis uses similarity and contrast principles by which commonality and mutual exclusivity, respectively, can be determined (Teddlie et al., 2009). Thematic analysis was applied to the eye tracking data showing patterns of fixations and scan paths as well as recurring usability problems.

3.10.2 Quantitative data analysis

Quantitative analysis is the process of presenting and interpreting numerical data. Descriptive statistics as well as inferential statistics was used to present the results and analysis of the e-Skills assessment data. Descriptive statistics include measures of central tendency such as averages - mean, median and mode, as well as measures of variability above or below the average such as standard deviation. Inferential statistics are the outcomes of statistical tests used for making deductions from the data collected and to test the hypotheses that have been set, and relating findings to the sample or population.

The analytic application, IBM Statistical Package for the Social Sciences (SPSS) version 20, was used in this research. Factor analysis was applied to the e-Skills assessment data. The e-Skills assessment questionnaire collected data on the students' perceptions of their knowledge and skills with regard to using myUnisa, Microsoft Word, Excel, PowerPoint, e-mail as well as the Internet. It required students to evaluate the extent to which they think the competence-based assessment tool used for the e-Skills assessment actually measured their knowledge of each of these applications.

3.10.3 Analysing usability data to identify usability problems

The variables that were used for analysis included fixations, fixation durations, saccades, and scan paths of the eye tracking data. The gaze plots provided qualitative data using the Tobii Studio software. This data includes transition matrices which are an indication of the relative randomness or directedness of the search. The heat maps which use colour-coding to indicate which areas participants look at the most, and the amount of time they spent looking, were analysed. Areas of interest (AOI) provided more quantitative analysis by indicating how often participants viewed specified areas. The observational data, video data and responses to questions in the questionnaire were analysed to identify usability problems.

3.10.4 Organising usability and eye tracking results

The participants' performance in the e-Skills assessment was used to categorise the participants into one of the four digital proficiency groups, that is, Digital Awareness, Digital Literacy, Digital Competence or Digital Expertise. This data was then related to the eye tracking data. Further statistical analysis was done based on the responses to the post-test questionnaire to ascertain participants' perceived ease of use, efficiency, effectiveness, memorability and satisfaction of the LMS. Observations and eye tracking data as well as data collected by using the questionnaires was used to associate compare the identified usability problems to the digital proficiency levels of the participants.

3.11 Ethical considerations

Caring about ethics and acting on that concern promotes the integrity of research, and affects the professional reputation and credibility of the research work of the researcher (Israel & Hay, 2006). Research ethics standards and values as outlined in the UNISA Research ethics policy were adhered to (Unisa Policy on Research Ethics, 1997). The official Unisa ethical clearance procedures were followed. The priority for this study was to inform potential participants of the purpose of the study and that sessions in the HCI laboratory would be videotaped. Potential participants were assured that there would be no repercussions if they chose not to take part in the study. Students were informed of how the information would be used as well as their right to choose whether to take part in the research or not, and the right to withdraw at any time during the research. Consent forms signed by each participant for the e-Skills assessment are shown in Appendix 2, and Appendix 4 shows consent forms for usability testing and eye tracking. Written consent was thus obtained from students who elected to participate.

3.12 Conclusion

This chapter has outlined the choices regarding the philosophy, strategy and research method selected for the study. As explained a pragmatic position was taken, and the deductive reasoning approach selected for the research. The case study selected, first year students at an ODL institution, represents a unique case as the institution has recently introduced compulsory online signature modules for all first year students who register with the institution. The hypothesis that “There is a relationship between the usability problems experienced by the students when using the LMS in an ODL environment and the students’ e-Skills competence”, was formulated. A mixed method was chosen to provide triangulation of quantitative and qualitative data.

The process used in the first component of the study to assess participants’ e-Skills using the competence-based e-Skills assessment was explained. Categorisation of the participants into the four levels of the e-Skills proficiency framework and the selection of representative participants who participated in the second part of the study was clarified.

The three tasks performed by the participants during usability testing and eye tracking in the HCI laboratory and the procedures used to conduct usability testing were explained. The data analysis techniques that would be used for analyses of the data were elucidated. The data collected and the findings of the research are presented in the following chapter.

Chapter 4: Findings

4.1 Introduction

The preceding chapter described how the research was carried out, the methodological and design choices made, the philosophy and strategy chosen for the study, as well as data collection procedures. This chapter presents the results that were obtained. The findings are reported on in line with the main research question and sub-questions stated in section 1.3.1. Section 4.2 describes how the participants were segmented according to their e-Skills levels based on the Digital Proficiency Framework described in section 2.4. The performance of participants in the three tasks during usability testing and eye tracking is then described for different digital proficiency levels. Section 4.3 presents the task completion times, and section 4.4 describes the usability problems that were experienced by participants with different levels of digital proficiency. Section 4.5 shows the results of the eye tracking tests and relates them to the usability problems observed.

4.2 Findings based on segmenting participants according to e-Skills levels

4.2.1 Results of online competence-based assessment

The percentage ranges shown in Table 4.1 were used to group participants into one of the four digital proficiency levels defined in the Digital Proficiency Framework (section 2.4), based on the mark obtained in the e-Skills assessment.

Table 4.1: Digital proficiency categories

Digital Proficiency level	e-Skills assessment (Range of % mark used for category)
Digital Awareness	0 – 9
Digital Literacy	10 - 29
Digital Competence	30 - 49
Digital Expertise	50 +

The results of the e-Skills assessment are shown in Figure 4.1 and Table 4.2. These results show that there were 15 (17%) participants in the Digital Awareness category, 40 (47%) in the Digital Literacy, 24 (28%) in the Digital Competence and 7 (8%) in the Digital expertise category. A total of 64% of the participants were in the two lower levels of digital proficiency, Digital Awareness and Digital Literacy. A total of 36% of the participants were in the two upper levels of digital proficiency, Digital Competence and Digital Expertise.

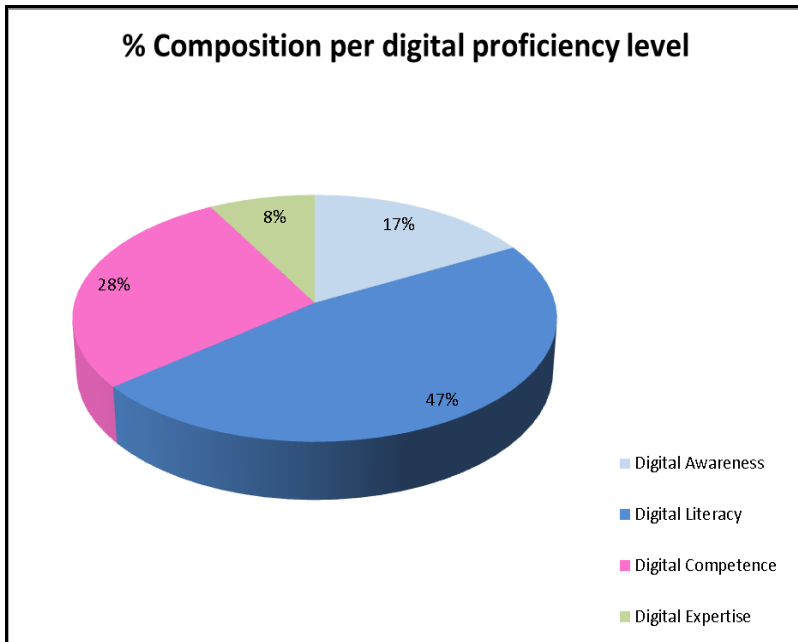


Table 4.2: Participants per digital proficiency level

Digital proficiency level (Framework described in section 2.4)	Number of participants	%
Digital Awareness	15	17
Digital Literacy	40	47
Digital Competence	24	28
Digital Expertise	7	8
Total	86	100

Figure 4.1: Percent Composition per digital proficiency level

4.2.2 Post-test questionnaire results

On completion of the simulated online competence-based e-Skills assessment each of the 86 participants completed the questionnaire shown in Appendix 3. The questionnaire was divided into two sections. The first section, Dimension 1, had seven questions and required participants to indicate their perceived competence in using MS Word, PowerPoint, Excel, e-mail, and the Internet. The questionnaire used a five-point Likert scale, where “1” represents “Not good at all” and “5” represents “Very good”. In the second section, Dimension 2, participants assessed the extent to which they believed the simulated competence-based assessment actually measured their competence in using Internet

search, e-mail, the MS Word, PowerPoint, and Excel applications, as well as their basic computer skills. There were six questions in this section.

The results obtained show that the highest rating was for the participants' self-assessment of their ability to use myUnisa, which equals 4.15 on the five-point Likert scale. The least mean rating was the participants' self-assessment of their ability to use MS PowerPoint, which equals 2.60 (Table 4.3). MyUnisa is the LMS that all registered students are expected to use. It is therefore no surprise that students' perception of their ability to use the system is high. Table 4.2 shows the means and standard deviations of the students' self-assessment of their e-Skills. The standard deviations were low ranging between 1.192 for myUnisa and 1.349 for MS Word.

Table 4.3: Mean and standard deviation of post-test questionnaire – Dimension 1

Dimension 1: Self-assessment of e-Skills	Mean	Std. Deviation
This is how well I rate my ability to use myUnisa	4.15	1.192
This is how well I rate my Basic Computer skills	3.54	1.201
This is how well I rate my Internet Search skills	3.85	1.294
This is how well I rate my ability to use Email	3.68	1.261
This is how well I rate my ability to use MS Word	3.56	1.349
This is how well I rate my ability to use MS PowerPoint	2.60	1.259
This is how well I rate my ability to use MS Excel	2.95	1.377

In Table 4.4 the mean of ratings of students' perception of the accuracy of the online assessment to accurately measure their ability to use different applications is shown. Students' perception of the accuracy with which the e-Skills assessment measured their ability to use the different applications was moderately high, ranging from 3.00 for MS PowerPoint to 3.73 for basic computer skills (Table 4.4). The students therefore perceived the online assessment as being able to accurately assess their e-Skills. This was confirmed by the low standard deviation which ranged between 1.176 and 1.432, indicating that most individual scores were close to the mean.

Table 4.4: Mean and standard deviation of post-test questionnaire – Dimension 2

Dimension 2: Accuracy of online assessment in assessing e-Skills (As perceived by participants)	Mean	Std. Deviation
My rating of accuracy of the Online Assessment of my Basic Computer skills	3.73	1.292
My rating of accuracy of the Online Assessment of my Internet Search skills	3.60	1.176
My rating of accuracy of the Online Assessment of my Email skills	3.35	1.294
My rating of accuracy of the Online Assessment of my MS Word skills	3.58	1.300
My rating of accuracy of the Online Assessment of my MS PowerPoint skills	3.00	1.432
My rating of accuracy of the Online Assessment of my MS Excel skills	3.25	1.345

4.2.3 Validity – Results of factor analysis of e-Skills post-test questionnaire

Factor analysis was used to test the validity of the e-Skills questionnaire (Appendix 3) completed by participants after the assessment. Validity is the degree to which the test measures what it is designed to measure. The results of the analysis in this section were produced using the IBM Statistical Package for the Social Sciences (SPSS), version 20.

In order for factor analysis to provide valid results, the number of respondents should be at least four times the number of variables, which are the questions or items, to be analysed (Eiselen, Uys & Potgieter, 2005). There were 13 of these variables in the questionnaire which used the five-point Likert scale, and the value obtained when the number of variables (13), when multiplied by 4, equals 52. The number of respondents was eighty six (86), which is more than four times the number of variables, therefore sufficiently large enough that the result of the factor analysis can provide valid results.

4.2.3.1 Item analysis

An item analysis was performed on the questions of each dimension in the quest to produce Cronbach Alpha values, to test the validity of the questionnaire. As discussed in section 3.8.1, the Cronbach Alpha value which indicates the internal consistency of the questions is interpreted as follows (Eiselen, Uys & Potgieter, 2005):

- If the value is > 0.8, reliability is good
- If between 0.6 and 0.8 reliability is acceptable, and
- If below 0.6, reliability is unacceptable

Table 4.5 and 4.6 show the Cronbach Alpha values obtained for the two dimensions. The output of the reliability analysis of the items in the first dimension, in which participants assess their skills in using the different applications, shows that the overall Cronbach Alpha value is 0.883. This reliability is adjudged, that is, reliability is good. The overall Cronbach Alpha value for the items in the second dimension in which each participant rated the accuracy of the online competence-based assessment in assessing their skills is 0.887. This reliability is also adjudged.

Table 4.5: Reliability Statistics - Dimension 1: Self-assessment of e-Skills

Cronbach Alpha	N of Items
.883	7

Table 4.6: Reliability Statistics - Dimension 2: Perceived accuracy of online assessment in assessing e-Skills

Cronbach Alpha	N of Items
.887	6

Table 4.7 and 4.8 show the mean values, standard deviation and Cronbach Alpha values of items for Dimension 1 and 2 respectively.

Table 4.7: Mean values, standard deviation and Cronbach Alpha values of items – Dimension 1

Dimension 1: Self-assessment of e-Skills	Mean	Std. Deviation	Item-Total Correlation
This is how well I rate my ability to use myUnisa	4.15	1.192	.567
This is how well I rate my Basic Computer skills	3.54	1.201	.725
This is how well I rate my Internet Search skills	3.85	1.294	.585
This is how well I rate my ability to use Email	3.68	1.261	.709
This is how well I rate my ability to use MS Word	3.56	1.349	.808
This is how well I rate my ability to use MS PowerPoint	2.60	1.259	.656
This is how well I rate my ability to use MS Excel	2.95	1.377	.655

The Cronbach Alpha values range between 0.6 and 0.8 (Table 4.7 and 4.8), which means that reliability is acceptable and the questions have internal consistency.

Table 4.8: Mean values, standard deviation and Cronbach Alpha values of items – Dimension 2

Dimension 2: Accuracy of online assessment in assessing e-Skills (As perceived by participants)	Mean	Std. Deviation	Item-Total Correlation
My rating of accuracy of the Online Assessment of my Basic Computer skills	3.73	1.292	.742
My rating of accuracy of the Online Assessment of my Internet Search skills	3.60	1.176	.625
My rating of accuracy of the Online Assessment of my Email skills	3.35	1.294	.832
My rating of accuracy of the Online Assessment of my MS Word skills	3.58	1.300	.866
My rating of accuracy of the Online Assessment of my MS PowerPoint skills	3.00	1.432	.715
My rating of accuracy of the Online Assessment of my MS Excel skills	3.25	1.345	.755

4.2.3.2 Results of Barlett’s test of Sphericity, Kaiser-Meyer-Olkin Measure and communalities

The results of the Barlett’s test of Sphericity, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value and Communalities are discussed in this section. The KMO is a statistic that indicates the proportion of variance in the variables that might be caused by underlying factors (Eiselen et al, 2005). If it is less than 0.6, factor analysis cannot be used. The values of the KMO for the two dimensions were 0.844 and 0.849 respectively (Table 4.9 and 4.10).

Table 4.9: KMO and Bartlett's Test – Dimension 1: Self-assessment of e-Skills

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.844
Bartlett's Test of Sphericity	290.592
Approx. Chi-Square df	21
Sig.	.000

Table 4.10: KMO and Bartlett's Test: Dimension 2: Perceived accuracy of online assessment in assessing e-Skills

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.849
Bartlett's Test of Sphericity	334.105
Approx. Chi-Square df	21
Sig.	.000

These values exceed 0.6 and therefore indicate that there is sufficient correlation between pairs of items in order to continue with factor analysis. The Bartlett's Test of Sphericity tests the null-hypothesis that all of the items are uncorrelated. It is necessary that this null-hypothesis be rejected otherwise factor analysis is inappropriate. Tables 4.9 and 4.10 also show the p-values (Sig.) of the Bartlett's test for Dimension 1 and Dimension 2.

The p-value (Sig.) of the Bartlett's test for both dimensions = 0.000, which is less than 0.05.

This means it is significant, an indication of a strong enough correlation between the questions to perform factor analysis. The dataset used in this study is therefore adequate for analysis as shown by the results of the Bartlett's test of Sphericity and the Kaiser-Meyer-Olkin (KMO) measure. The extent to which each question correlates to the other questions is indicated by the Communalities (Table 4.11 and 4.12). The Communalities for Dimension 1 and 2 Table are shown in Table 4.11 and 4.12 show respectively.

Table 4.11: Communalities – Dimension 1: Self-assessment of e-Skills

Dimension 1: Self-assessment of e-Skills	Mean	Initial	Extraction
This is how well I rate my ability to use myUnisa	4.15	1.000	.459
This is how well I rate my Basic Computer skills	3.54	1.000	.657
This is how well I rate my Internet Search skills	3.85	1.000	.485
This is how well I rate my ability to use Email	3.68	1.000	.633
This is how well I rate my ability to use MS Word	3.56	1.000	.763
This is how well I rate my ability to use MS PowerPoint	2.60	1.000	.567
This is how well I rate my ability to use MS Excel	2.95	1.000	.575

Table 4.12: Communalities – Dimension 2: Perceived accuracy of online assessment in assessing e-Skills

Dimension 2: Accuracy of online assessment in assessing e-Skills (As perceived by participants)	Mean	Initial	Extraction
My rating of accuracy of the Online Assessment of my Basic Computer skills	3.73	1.000	.704
My rating of accuracy of the Online Assessment of my Internet Search skills	3.60	1.000	.574
My rating of accuracy of the Online Assessment of my Email skills	3.35	1.000	.804
My rating of accuracy of the Online Assessment of my MS Word skills	3.58	1.000	.843
My rating of accuracy of the Online Assessment of my MS PowerPoint skills	3.00	1.000	.756
My rating of accuracy of the Online Assessment of my MS Excel skills	3.25	1.000	.699

Values indicated in the extraction column that are closest to 1 indicate a high correlation of the each question to the other questions. All the Communalities of the questions in the questionnaire are acceptable since they are more than 0.4. If the values of the Communalities were less than 0.4, they would be unacceptable. The values of 1.000 in the initial column represent the starting point for the iterative process that ends with the extraction communalities (Eiselen, Uys & Potgieter, 2005).

4.2.4 Conclusion – segmenting participants according to e-Skills levels

The results show that:

There is a relationship between the two dimensions, that is, how the participants rate their e-Skills competence (Dimension 1), and how they perceive the simulated online competence-based assessment to accurately assess their e-Skills (Dimension 2).

The use of the simulated online competence-based e-Skills assessment in categorising participants is therefore acceptable. This forms a basis for the second phase of the research in which the usability problems experienced by students with varying levels of digital proficiency are investigated.

As indicated in section 3.7 the proposition stated in the alternative hypothesis (H_1) is that:

There is a relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students' e-Skills competencies, and

The null hypothesis (H_0) is that:

There is no relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students' e-Skills competencies.

This empirical inquiry will result in the alternative hypothesis (H_1) being accepted if the null hypothesis (H_0) can be disproved, else the alternative hypothesis (H_1) will be rejected if the null hypothesis (H_0) cannot be disproved.

4.3 Usability testing – Task completion times

4.3.1 Introduction

Usability studies involve consideration of the performance and observations made when participants carry out assigned tasks. This includes measures such as time taken to complete the task, the percentage of participants who succeeded in completing the task, the type and number of errors, as well as the subjective ratings of ease of use of the system (Dumas & Redish, 1999; Nielsen et al., 2009). Similarly, in this research, and as outlined in section 3.10.5 and 3.10.6 usability testing and eye tracking were used to collect data on participants' performance on three tasks using the LMS at the Human-Computer Interaction laboratory. The results of this investigation are presented in the following sections. Efficiency, a measure of usability (section 2.2.2), was determined based on the amount of time that users in different e-Skills levels took to complete each of the three tasks. The performance of the participants in the four levels of digital proficiency, namely Digital Awareness (DA), Digital Literacy (DL), Digital Competence (DC) and Digital Expertise (DE), are discussed for each of the three tasks. The amount of time taken by participants in different levels of digital proficiency to complete the tasks and the usability problems they experienced are outlined.

4.3.2 Task completion times

The amount of time participants took to complete the tasks is shown in Table 4.13, and her discussed in sections 4.3.3 to 4.3.5.

Note that the colours used for each of the digital proficiency levels is maintained throughout this section for ease of reference.

Table 4.13 – Task completion times of participants in different e-Skills levels

		Task Completion times (minutes)				
Digital Competence	Participants	Task 1	Task 2	Task 3	Total amount of time	
Digital Awareness	DA1	10	4	9	23	
	DA2	5	2	4	11	
	DA3	12	1	8	21	
	DA4	6	1	1	8	
	DA5	10	1	2	13	
	Average	9	2	5	15	
Digital Literacy	DL1	10	1	6	17	
	DL2	11	4	6	21	
	DL3	5	3	1	8	
	DL4	4	1	7	12	
	DL5	7	1	3	11	
	DL6	7	1	1	9	
	Average	7	2	4	13	
Digital Competence	DC1	5	1	4	10	
	DC2	5	1	2	8	
	DC3	7	1	1	9	
	DC4	5	1	1	7	
	DC5	5	1	1	7	
	DC6	4	1	1	6	
	Average	5	1	2	8	
Digital Expertise	DE1	5	1	1	7	
	DE2	3	1	1	5	
	DE3	4	1	1	6	
	DE4	4	1	1	6	
	Average	4	1	1	6	

4.3.3 Task 1 – Send an e-mail

In this task participants had to login to the myLife e-mail system and send an e-mail with a specified attachment to a given e-mail address. Participants had to browse for the correct document and attach it to the e-mail, and send it. The results show a clear distinction between the first two Digital Proficiency levels, that is Computer Awareness and Digital Literacy, in comparison to the other two levels, Digital Competence and Digital Expertise.

All participants (100%) in both the Digital Competence and Digital Expertise categories completed Task 1. In contrast, 40% of those in the Digital awareness category, and 67% in the Digital Literacy categories completed the task.

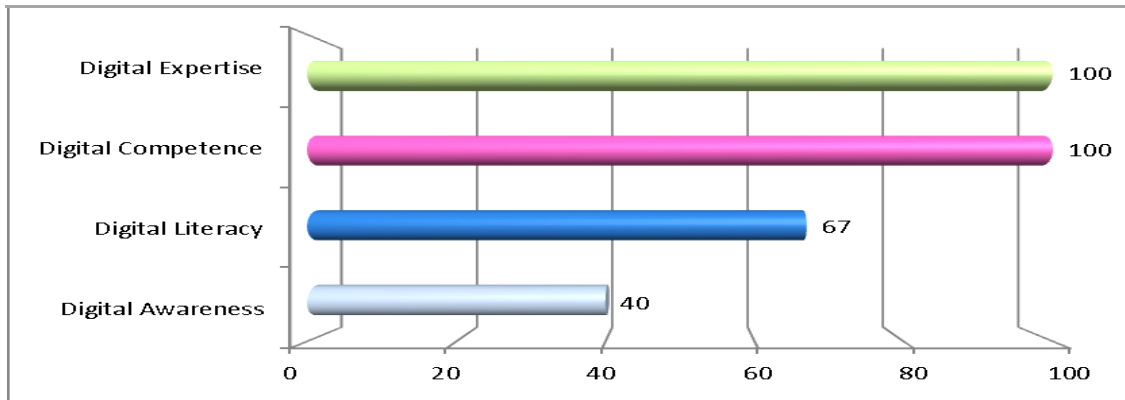


Figure 4.2: Task 1 - Send e-mail: % of participants who completed the task

All of the participants in the Digital Awareness category who completed the task needed assistance. Some of the comments made by these participants were:

- “I don’t know this thing ‘@’, where is it?”
- “How do I attach a file to the e-mail”
- “How do I send the e-mail?”

Sixty percent (60%) of participants in the Digital Awareness category needed to be shown where “@” is positioned on the keyboard.

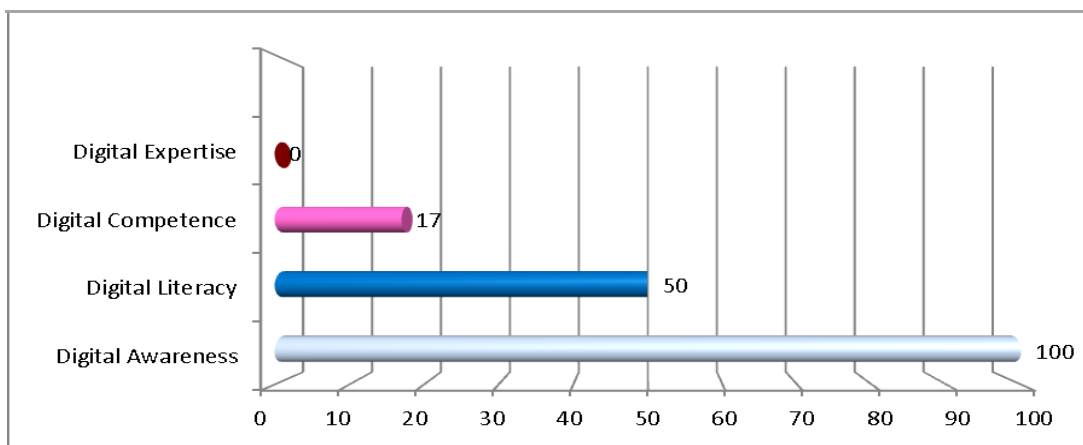


Figure 4.3: Task 1 Send email - % of participants who required assistance

All participants in the Digital Awareness category who completed the task had to be assisted to attach the file to the e-mail. It can be noted that all the participants who completed the task had correct login details and their login was correct in the first attempt. This could be an indication of familiarity with the e-mail system. However, the rest of the participants in this category, 60%, could not remember their passwords and struggled to login to the e-mail system, even after being provided with alternative logon details prepared for this purpose. The task completion time in the Digital Awareness category ranged between six (6) and ten (10) minutes for those who completed the task and the participants who did not complete the task spent between five (5) and twelve (12) minutes of attempting to do it. The average time for completion of Task 1 by participants in the Digital Awareness category was nine (9) minutes.

In the Digital Literacy category, 33% of participants did not complete the task. The reasons for non-completion include mistakenly pressing an incorrect key, and taking too long to login. Fifty percent (50%) of participants in this category could not remember their passwords and had to use the alternative login details specifically prepared for these occurrences. Although 67% of the participants in this category completed the task, 33% the participants committed some errors during the performance of the task. These included typing incorrect details during login, resulting in two to three login attempts.

Some errors made by participants in the Digital Literacy category include using the National "ID" number, which is the Identity document number, as a "UserID", instead of the allocated UserID. Another error was committed when a participant attached the document to the same e-mail more than four times because they did not realize that the document was already attached. Eventually they opened the document, cut and pasted the contents of the document into the e-mail. Possible causes of these errors are discussed in section 4.4.2 where usability problems experienced are presented incorporating the interview responses of participants. The task completion time among participants in the Digital Literacy category ranged between four (4) and eleven (11) minutes, and the average time for the completion of Task 1 was seven (7) minutes.

In the Digital Competence category, 83% of participants completed the task without any assistance, and 17% completed the task with minimum assistance as a result of errors made. These errors included incorrect login details and typing the e-mail address incorrectly. However, once these were corrected all participants completed the task without any further assistance. There were no errors made during the completion of the task and no assistance was required. In the Digital Expertise category the participants did not require any assistance during the task. The task completion time ranged between three (3) and five (5) minutes for participants in the Digital Expertise category, and between four (4) and seven (7) minutes for the Digital Competence category. The average time for completion of this task by participants in the Digital Expertise category was four (4) minutes, and five (5) minutes for the Digital Competence category (Table 4.12).

4.3.4 Task 2 – Find tutorial letter 101

This task involved finding a resource, a tutorial letter, of a module in the LMS. This required that the participant logon to the LMS, myUnisa, click on “Official Study Material” and select the tutorial letter. The usability results show 100% completion rate for this task, among participants in all four categories. All participants had correct login details to myUnisa for this task. This means that the participants are aware of myUnisa and that they need to assess the LMS using the correct login details.

In both the Digital Competence and Digital Expertise categories, all participants completed the task without any assistance. Although there was 100% completion rate in the Digital Literacy category, 17% of the participants needed assistance. In the Digital Awareness category 40% needed assistance. The task completion time for participants in the Digital Awareness category ranged between one (1) and four (4) minutes. This task was completed faster compared to the other two tasks, by all participants. The average task completion rate was one minute for participants in both Digital Expertise and Digital Competence categories, and two minutes for the Digital Awareness and Digital Literacy categories (Table 4.14). Most participants did not make errors, except for 40% of the participants in the Digital Awareness category who needed assistance.

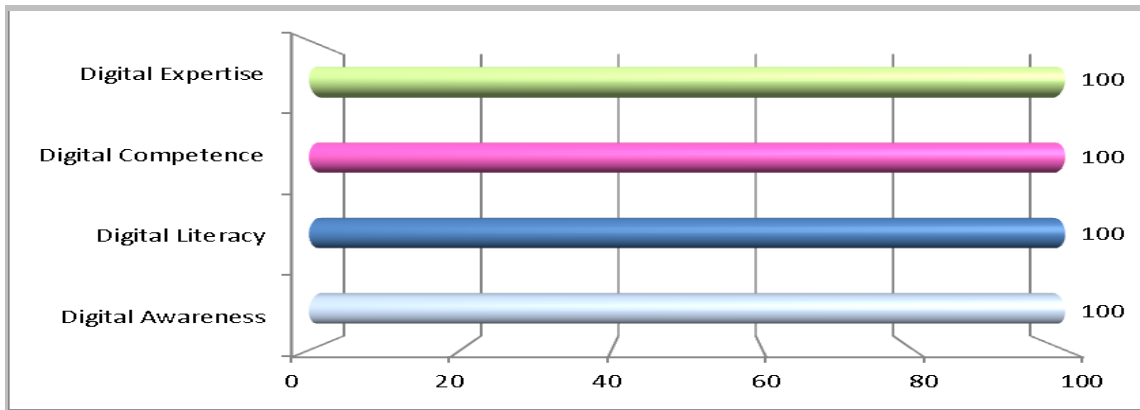


Figure 4.4: Task 2 - Find tutorial letter: % of participants who completed the task

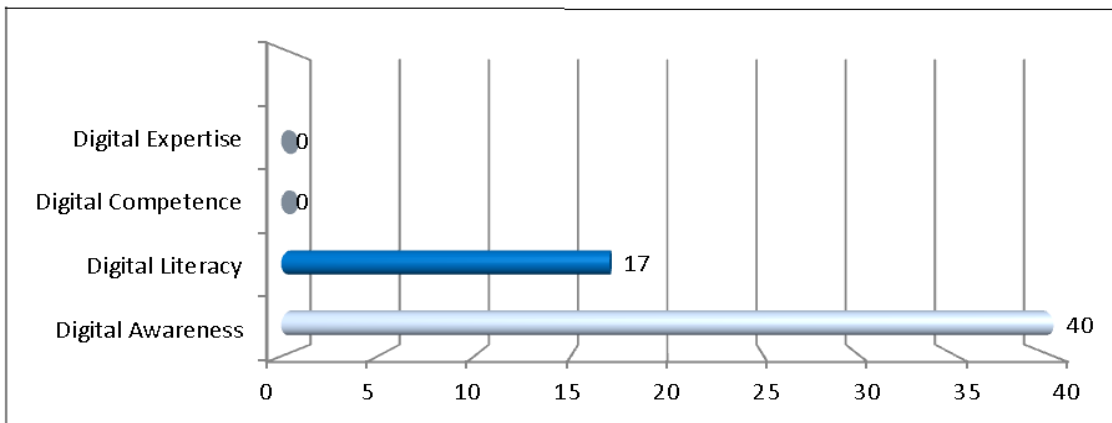


Figure 4.5: Task 2 - Find tutorial letter: % of participants who required assistance

4.3.5 Task 3 – Post a comment on the discussion forum

This task involved posting a comment on a discussion forum of a study module in the LMS. The task required participants to login to the LMS, myUnisa, select “Discussion Forum”, choose an ongoing discussion forum, write a comment and submit it. Figures 4.6 and 4.7 show the results.

The completion rate among participants in the two categories, Digital Competence and Digital Expertise was 100%. The task completion time among participants in the Digital Competence category ranged between one (1) and four (4) minutes. Seventeen percent (17%) of these participants required assistance. The completion rate among participants in

the Digital Literacy category was 100%. The average task completion rates for participants in the Digital Expertise category was one (1) minute, and two (2) minutes for participants in the Digital Competence category. For participants in the Digital Literacy category the average task completion rate was four (4) minutes. The task completion rate was between one (1) and seven (7) minutes. Fifty (50) % of the participants in the Digital Literacy category needed assistance. However, the task completion rate among participants in the Digital Awareness ranged between one (1) and nine (9) minutes. The average task completion time was five (5) minutes. The completion rate was 80%. Sixty (60) % of the participants needed assistance.

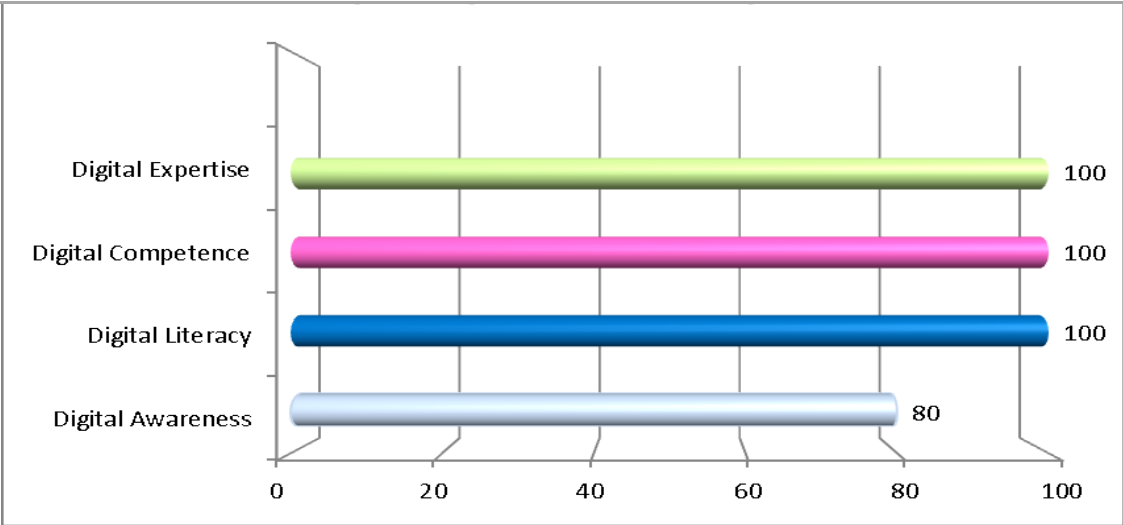


Figure 4.6: Task 3 – Post comment: % of participants who completed the task

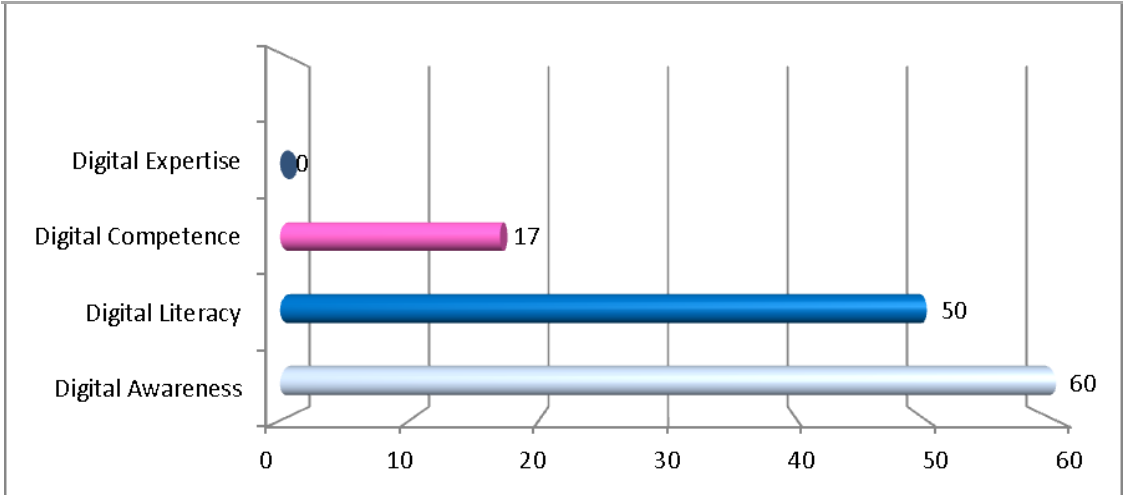


Figure 4.7: Task 3 - Post comment: % of participants who required assistance

4.3.6 Discussion – Task completion times

In Task 1 all the participants in the Digital Awareness category required assistance, and 50% of participants in the Digital Literacy category required assistance while performing the task. In contrast, none of the participants in the Digital Expertise category and 17% in the Digital Competence category required assistance. Some of the participants in the Digital Awareness group needed to be shown where to click in order to attach the file, and what to select to send it. Comprehension of concepts such as “Attach” were misunderstood by some of the participants in the Digital Awareness and Digital Literacy categories, but were however easily comprehended by participants in the Digital Competence and Digital Expertise levels. There were fewer questions and requests for assistance from the latter group.

Task 2 was completed by all participants. Only 40% of participants in the Digital Awareness category and 17% in the Digital Literacy category required assistance. None of the participants in the Digital Competence and Digital Expertise categories required assistance for this task.

In Task 3, participants in the Digital Competence and Digital Expertise categories committed more errors than they had in the other two tasks. Inability to identify the textbox in which to write the comment, and the “Submit” button were the two most common errors. Even participants in the Digital Awareness and Digital Literacy categories said that they found this task to be simple. Some of the comments however pointed to other factors that seem to have had an influence in the type of problems that were experienced by participants who did not perform well in this task. For example, participant DL2 commented saying, “I’m not good with computers”. When the same participant was asked if she uses the computers at the regional learner centre close to where she lives, she said she never goes there. The reason for this, she said, is that she works and studies part time and does not have time. This participant said she does not use myUnisa often, perhaps once a month, and as such mostly relies on printed tutorial material.

Participants in the Digital Competence and Digital Expertise categories found the tasks easier to do. Participant DC3 even remarked “I use myUnisa fulltime.” Notably, participants in the Digital Competence and Digital Expertise categories said that they use myUnisa frequently, mostly accessing it at the regional learner centre. Those who use it at home have their own computers and others access limited functions of the LMS using mobile phones. Participant DE3 even had a laptop with him at the usability testing session. Participant DE1 stated that he has a desktop computer at home and also accesses myUnisa using the cellphone. Participants in the Digital Expertise group have all used computers at high school which may explain the relatively higher confidence they demonstrated in performing the tasks.

4.4 Usability problems experienced by participants

4.4.1 Introduction

Some of the usability problems experienced by participants have been stated in the preceding section, section 4.3. In this section the usability problems are further discussed, incorporating findings of semi-structured interviews held with each participant at the end of each usability session. The interviews were video recorded to enable the researcher to replay and analyze them. Some questions asked by the facilitator during the interviews were similar for all participants, while other questions were formulated in response to a participant’s actions as observed by the facilitator while the participant performed the three tasks.

Providing a set of criteria that defines what constitutes a usability problem can provide a shared understanding of what constitutes a usability problem (Hertzum et al., 2010). However, this can cause certain types of problems to be missed, and developing such criteria is difficult because it is affected by what system is being evaluated, the tasks, and the purpose of the evaluation. For this reason the usability problems that participants experienced while using the LMS in this study, are considered in view of the definition by Hertzum and Jacobsen (2010) discussed in section 2.2.5, that usability problems are the parts of the system interface that cause users trouble, slow them down, or fit badly with

their preferred ways of working. Usability problems experienced by participants in each of the digital proficiency levels are identified for each of the three tasks.

Effectiveness measures the success and accuracy with which users achieve the goals (section 2.2.2). The number of errors encountered, give an indication of effectiveness. In this section reference to “DA1” means participant number 1 in the Digital Awareness category, while “DE1” means participant 1 in the Digital Expertise category. A similar reference is used in all the categories when reference is made to a specific participant.

4.4.2 Task 1 – Send an e-mail

In Task 1, as described in section 3.10.6, participants had to send an e-mail to the specified address and attach the given document. This is an essential skill that a student in an ODL environment should have, and enables students to communicate with peers and instructors.

Table 4.14 shows a summary of the usability problems recorded for Task 1. The usability problems that were experienced by participants in the Digital Awareness category include inability to access myLife e-mail due to invalid login details. DA1 and DA2 tried to login, but the system response, “incorrect login details” was displayed. Participants in the Digital Literacy category encountered the same problem. Participants DL1 and DL2 were also unable to access myLife e-mail due to invalid login details. Participants DL1 and DL2 tried to justify why they did not have the correct e-mail login details. They ascribed this to the fact that they study part time as they are employed, implying that they do not have enough time to spend using the system as often as they would like.

Table 4.14 Summary of usability problems recorded for Task 1

No	Usability problems	Participants who experienced problem			
		DA	DL	DC	DE
	TASK 1				
1	<ul style="list-style-type: none"> The myLife icon was not clearly visible 	DA2 DA3 DA4 DA5	DL1 DL2	DC4	DE1 DE3
2	<ul style="list-style-type: none"> System required two login details, resulting in myLife login details not being remembered although myUnisa login details were known 	DA1 DA2	DL1 DL2		
3	<ul style="list-style-type: none"> The error message that popped-up during login to myUnisa was not visible to the user who did not seem to differentiate it with the background 	DA1			
4	<ul style="list-style-type: none"> The system did not give adequate support or error messages for participants with less e-Skills efficiency; users who did not know position of "@" during login process could not continue 	DA1 DA3 DA5			
5	<ul style="list-style-type: none"> Help documentation For participants who did not identify where to click to add an attachment to an e-mail, the online assistance on how to do this was not easy to find 	DA4 DA5	DL1 DL6		
6	<ul style="list-style-type: none"> The system did not provide clear information about what login details were required to access myLife. A participant even attempted to use their National "ID" document number instead of the Username. 		DL2		
7	<ul style="list-style-type: none"> The system did not provide an error message to indicate to the user that the document was already attached to the e-mail, even when the user repeatedly attached the same document 4 times, and eventually opened, cut and pasted it to the e-mail 		DL5		

The two usability problems that were remarkably unique were observed in the Digital Literacy category. The first was when participant DL2 attempted to login to myLife using the national "ID" number. This indicates miscomprehension of the concept of a login ID. The second one was when participant DL5 attached the same document to the same e-mail 4 times. The participant did not realise that he had already attached the document. Instead he kept clicking on the file and attaching it. Eventually he opened the file, copied

and pasted the contents into the e-mail. An explanation for the participant's behavior is a misunderstanding of the concept of "Attachment". As stated by the participant, he did not understand the difference between the "Attach" field and the message area where he expected to see the contents of the document that he was attaching. During the interview the participant said he did not realise that the file was already attached. However the interface uses the MS Word icon and name of the document in the "Attached" field as an indication that the document is attached. This was not understood by the participant.

As noted in section 4.3.2, 60% of participants in the Digital Awareness category, and 50% in the Digital Literacy category could not remember their myLife login details. Although alternative login details were provided to these participants, they still struggled to login to the myLife e-mail system. This could be an indication of unfamiliarity with the e-mail system. Notably, participants who completed the task all had correct login details, and login was correct in the first attempt.

4.4.2.1 Task 1 – New simplified login process to the LMS

This section only makes a note of a recent development that took place after this research was carried out. During the writing of this report an upgraded version of the LMS was implemented in which usability problem resulting from two logon processes was addressed. The new and simplified interface uses one login for both the myLife e-mail system and the other part of the LMS with the discussion forum, study material and other tools. When this change was introduced, it was announced that "the LMS is an essential part of every student's journey and the changes have been introduced to make the system effective and easy-to-use in the quest of making the institution a digital institution" (Unisa e-connect, 2013). Ease of use and effectiveness, as discussed in section 2.2.1 and 2.2.2, are attributes of usability.

4.4.3 Task 2 – Find tutorial letter 101

Task 2, detailed in section 3.10.6, required participants to find a tutorial letter for the specified module. The participants had to login to the LMS, browse to the relevant webpage and open the tutorial letter. In the Digital Awareness group one of the

participants, participant DA1, did not respond to the pop-up screen message during login to myUnisa. The question on the pop-up screen was “Do you want Internet Explorer to remember your password?” The participant did not seem to relate the pop-up message to their earlier input or the task at hand. When told to select “NO”, the participant asked “Where is it?” In the Digital Literacy category, participants DL4 and DE4 did not see Tutorial Letter 101 for the first module selected, which was the correct module, even though it was in the list of resources of the webpage they had opened. The participants then repeated the task using a different module, resulting in the participants taking more time to complete the task. Table 4.15 shows a summary of the usability problems recorded for Task 2.

Table 4.15: Summary of usability problems recorded for Task 2

No	Usability problems experienced	Participants who experienced problem			
		DA	DL	DC	DE
	TASK 2				
1	<ul style="list-style-type: none"> The correct option was not visible and users selected other options instead of Official study Material 	DA1 DA2 DA3	DL4		DE3 DE4
2	<ul style="list-style-type: none"> Language used does not clearly describe the option for the user: Official study material option not considered as option for accessing the Tutorial letter 101, and therefore users did not recognize this as the correct icon to select 	DA2	DL4 DL3	DC3	

The login process to the LMS was a problem to some participants in that the two different logins were required, one to access the myLife e-mail and another one to access the other tools of the LMS such as the Discussion Forum and the Resources facilities where study material are found. More students could remember their login details to myUnisa than their myLife login details. The results of this study confirms the difficulty students had with the use of two separate login processes, which has since been streamlined by myUnisa designers into a single process as presented in the next section.

4.4.4 Task 3 – Post a comment on the online discussion forum

Task 3, outlined in section 3.10.6 required that participants post a comment on the online discussion forum (ODF) on a topic being discussed. Discussion forums provide an opportunity for ODL students to be part of a learning community. Table 4.16 shows a summary of the usability problems recorded for Task 3.

Table 4.16: Summary of usability problems recorded for Task 3

No	Usability problems experienced	Participants who experienced problem			
		DA	DL	DC	DE
	TASK 3				
1	<ul style="list-style-type: none"> Discussion Forum option not easily seen or selected in order to post the comment 	DA1	DL2 DL4		DE3
2	<ul style="list-style-type: none"> Option to select in order to navigate to an on-going discussion not clear, resulting in user selecting <i>Add new topic</i> 		DL 5	DC4	
3	<ul style="list-style-type: none"> Language or terminology used not easy to understand; the user did not understand the instruction “Post a comment”, but understood when it was explained as “write a comment” 	DA1			
4	<ul style="list-style-type: none"> Typing area for writing the comment and the <i>Submit</i> button were not visible unless the user scrolled down; Some users did not see where to type the comment, or where to click, to <i>Submit</i> once the comment had been typed, and had to be instructed to scroll down 	DA1 DA3		DC3	DE1
5	<ul style="list-style-type: none"> Inadequate feedback was provided for a repeated error where the user kept clicking on the first comment posted on the first comment posted on the discussion forum (10 times) trying to “open” it, until instructed to scroll down 	DA3			
6	<ul style="list-style-type: none"> The visible area below the last comment seemed to be the typing area; the correct typing area was not visible resulting in users attempting to type the comment at the wrong place 	DA1 DA3			
7	<ul style="list-style-type: none"> Interactive messages given as feedback to indicate that the comment that they had written had been posted, which read “<i>Your reply has been successfully recorded</i>”, was not seen 		DL1		DE1 DE3

In the Digital Awareness category, participant DA1 and DA3 did not see where to type the comment. Participant DA1 incorrectly tried to type immediately below the last comment, and eventually asked “Where do I type? Here or this one?” Participants DL2 and DL4 were hesitant and unsure what option to select and requested assistance. In the Digital Competence category participant DC3 did not immediately recognise the part of the screen where he was supposed to type the comment. Participant DC2 did not select the “Submit” option in order to post the comment. When asked about this, the participant said “I forgot”. There was also no error message to notify the participant of this mistake. Likewise, in the Digital Expertise category, Participant DE1 did not see where to type the comment, until told to scroll down. The participant needed to scroll down in order to see where to type

(Figure 4.8). A related usability problem was caused by the location of the Submit button, which was not immediately visible and required the participant to scroll down to find it. A participant in the Digital Awareness category, DA1 seemed not to understand the difference in the concepts of “Posting” and “Attaching”. After typing the comment participant DA1 asked where the comment should be “attached”.

In this task participants in the Digital Expertise category seemed to experience the most usability problems. For instance, Participants DE1 first selected Additional Resources instead of Discussion Forum, and the same participant did not see where to type the comment (Figure 4.8 and Figure 4.10).

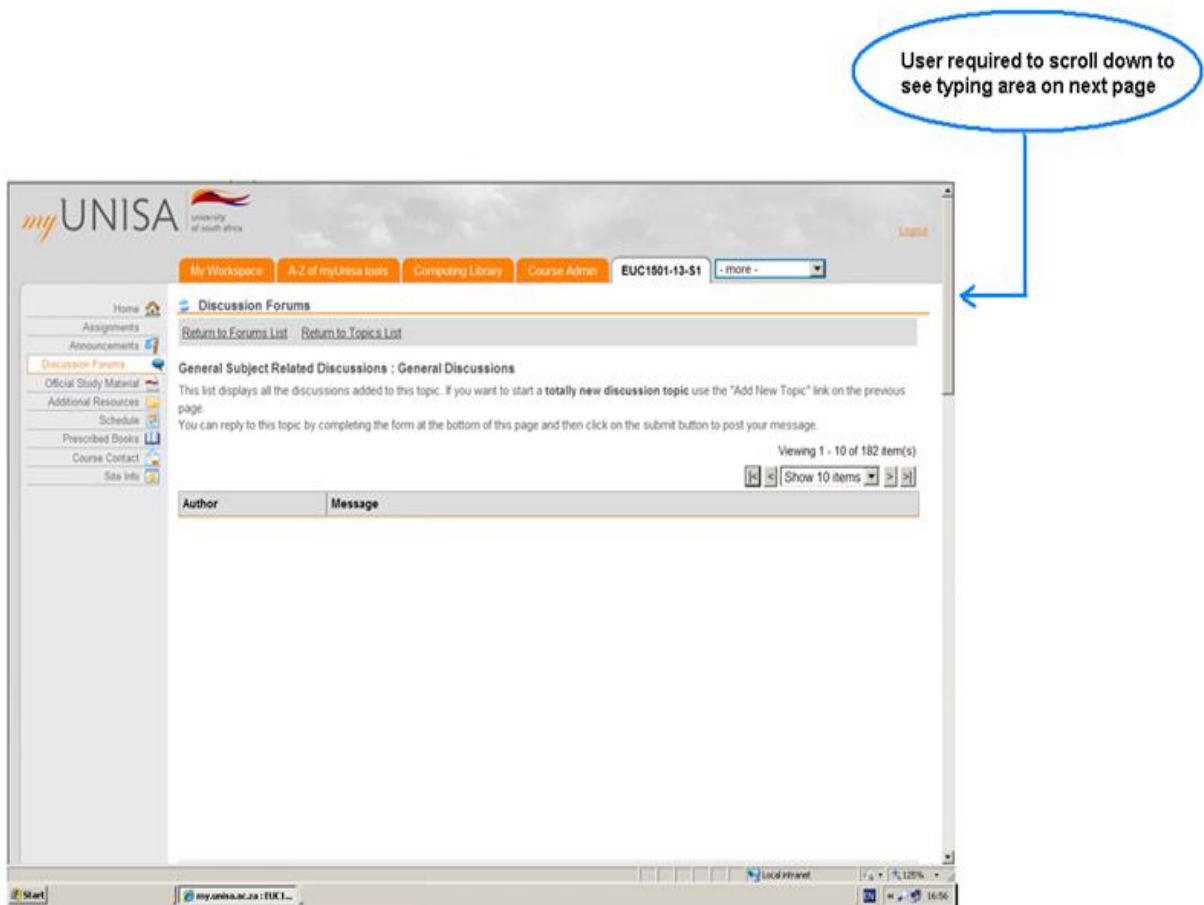


Figure 4.8: Task 3 – Before scrolling down

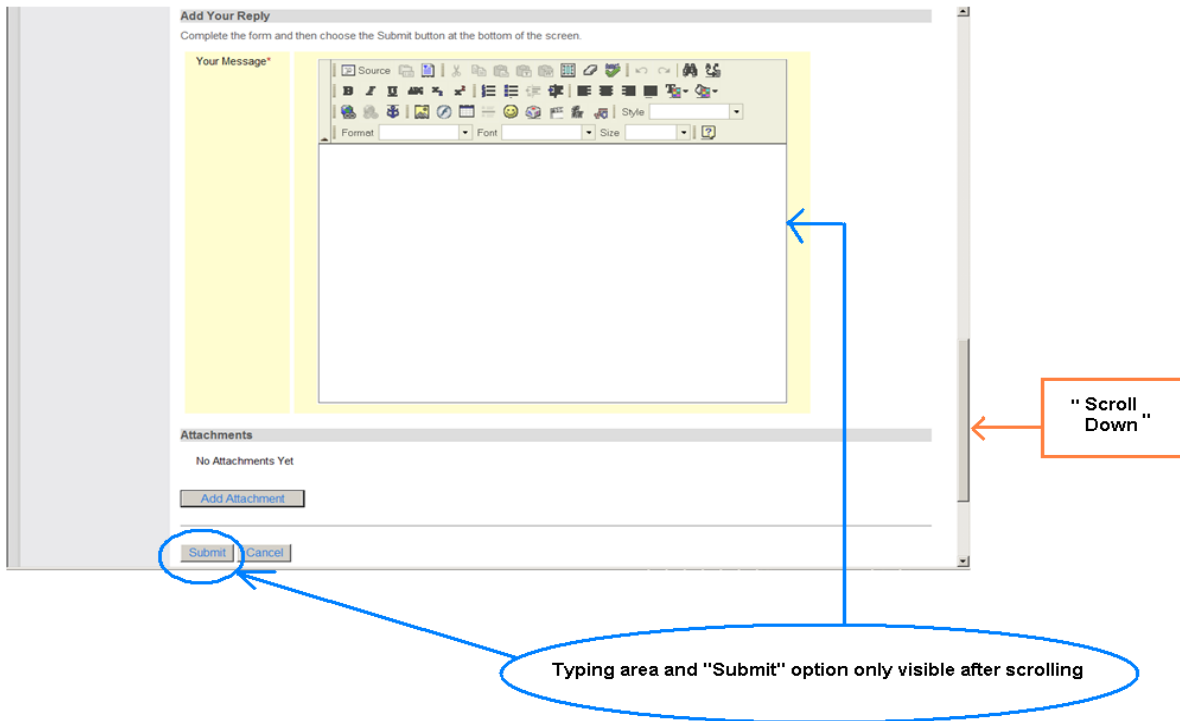


Figure 4.9: Task 3 - After scrolling down

The user interface requires that the user should scroll down the Webpage in order to see the typing area. Similarly the user needs to scroll down in order to see the Submit button. There was no error message on the screen to make the user aware that the user should scroll down. Developers of user interfaces need to be aware of the possibility of such a usability problem and give clearer indication for the user to scroll down or place the Submit button in a visible position.

4.4.5 Discussion

The usability problems of participants in the different digital proficiency levels were found to be influenced by participants' differences in comprehension of concepts as well as differences in self-efficacy. The ability to understand "computer language" or concepts such as "Attach", "Post" were observed to be limited in some of the participants in the Digital Awareness and Digital Literacy categories. Self-efficacy and general confidence in one's abilities seem to be more demonstrated by participants in the Digital Expertise and Digital competence categories in comparison to participants in the Digital Awareness and Digital

Literacy levels. This is demonstrated in the following examples. Participant DA1 remarked “I did not expect to be able to do some of the tasks, especially me because I do not use computers often, and I do not have one at home”. Similar remarks were made by Participant DL2 that, “I am not good with computers”. In contrast 2 of the participants in the Digital Expertise category, DE1 and DE4 who although at the start of the third task said they had not used the online discussion forum (ODF) before, both performed as well as the others in the same category who said they had used it before, and better than participants in the other categories. When asked about this, both participants DE1 and DE2 remarked that “the user interface is simple and clear”. This can be interpreted as an indication of the influence of self-efficacy.

Although these participants had not performed the specific tasks before, they showed a high level of belief in their ability to do the task. Participants in the Digital Expertise and Digital Competence categories were quicker to login, access the discussion forum and noticeably, typed the exact message as given in the instruction. Conversely, participants DA1, DA3, DA5, DL1, and DL2 took their time to read other comments posted on the online discussion forum, and then wrote their own comments. Participant DL1 even had time to search for a “Smiley face” icon and to add it to her comment. The ability to read and comprehend instructions seems to be an influencing factor for the way in which some participants performed the tasks. For example, in Task 2, Participant DL2 did not read instructions and required assistance throughout the task, asking what it is that they were supposed to do, despite having been given the instruction onscreen earlier.

4.5 Usability testing and eye tracking - heat maps and gaze plots

4.5.1 Introduction

Eye tracking, as outlined in section 2.2.5, was used together with usability testing for usability evaluation in this study. Usability testing discussed in section 2.2.4, is an evaluation method used in user-centered interaction design, for collecting empirical data during which representative users are observed when interacting with the system and carrying out typical tasks (Rubin & Chisnell, 2008; U.S HHS, 2006). When using the eye

tracking technique, heat maps and gaze plots are generated using eye tracking software to show the attention patterns (Bojko, 2009). The eye tracking results provide visual evidence in the form of heat maps and gaze plots (discussed in section 2.2.6). The following sections outline the heat maps and gaze plots of participants in the four different levels of digital proficiency produced during usability testing in the Human-Computer Interaction laboratory (HCI lab). Section 4.5.2 presents heat maps and gaze plots are discussed in section 4.5.3.

4.5.2 Heat maps

Heat maps, discussed in section 2.2.6, are eye tracking visualisations that graphically represent accumulated focusing time as colours (Chen et al, 2010). In this section each of the three tasks are discussed using “combined” heat maps for participants in each digital proficiency category. The screen layout for the scene under discussion is first presented to show the area of interest for the scene.

4.5.2.1 Task 1 – Send an e-mail

In Task 1 participants had to send an e-mail to the specified address and attach a specified document to the e-mail address. Figure 4.10 shows the “Area of interest” for this scene, the “myLife e-mail icon” which users needed to select to access their e-mail.

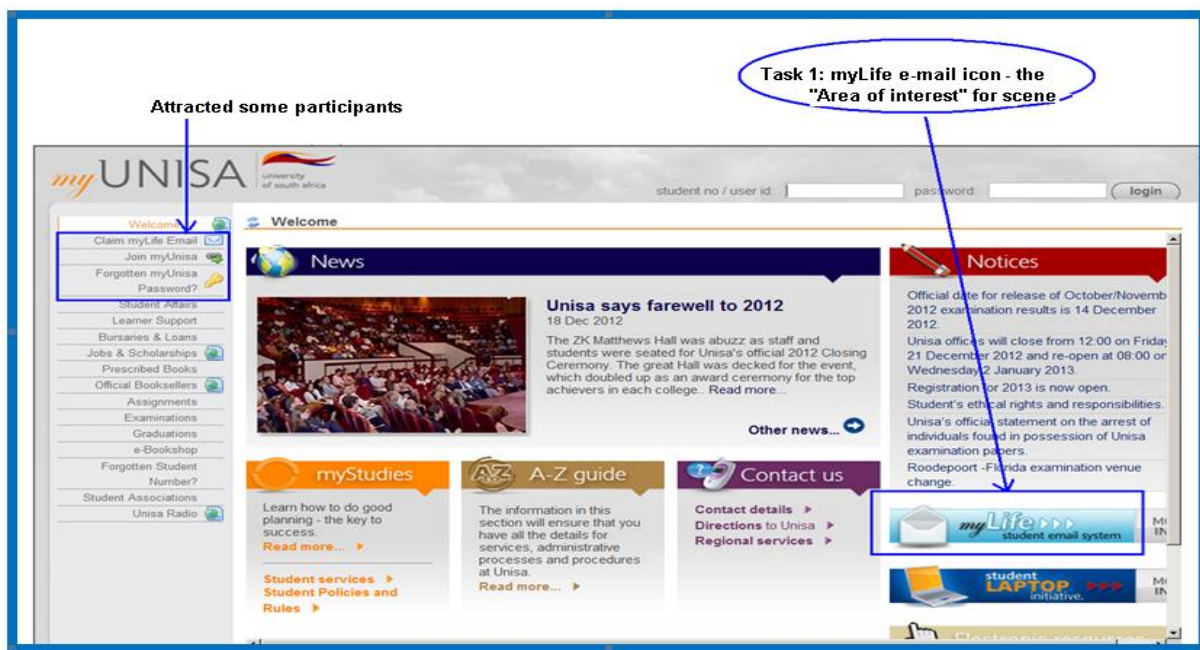


Figure 4.10: Task 1 – Screen layout of myUnisa login page – Send e-mail

Figures 4.11 to 4.14 show combined heat maps for participants in each of the digital competence levels. The participants in the Digital Awareness category, in Figure 4.11, did not focus on the myLife e-mail system icon. They focused on the upper left corner where there are options to register for the myLife account. The heat map for participants in the Digital Literacy category (Figure 4.12) and, to a lesser degree, the Digital Competence category, (Figure 4.13), is similar to that of the Digital Awareness participants (Figure 4.11). The myLife e-mail system icon was not the focus – participants focused more on the upper left corner. Figure 4.12 for the Digital Literacy category also shows that the words “Contact Us” next to the myLife e-mail icon attracted the attention of participants. There is however comparatively more focus on the myLife e-mail icon in the Digital Competence category than in both the Digital Awareness and Digital Literacy categories. In contrast, the combined heat map of participants in the Digital Expertise category shows that the participants focused their attention on the myLife e-mail icon on the right hand side (Figure 4.14), which was the relevant task area.

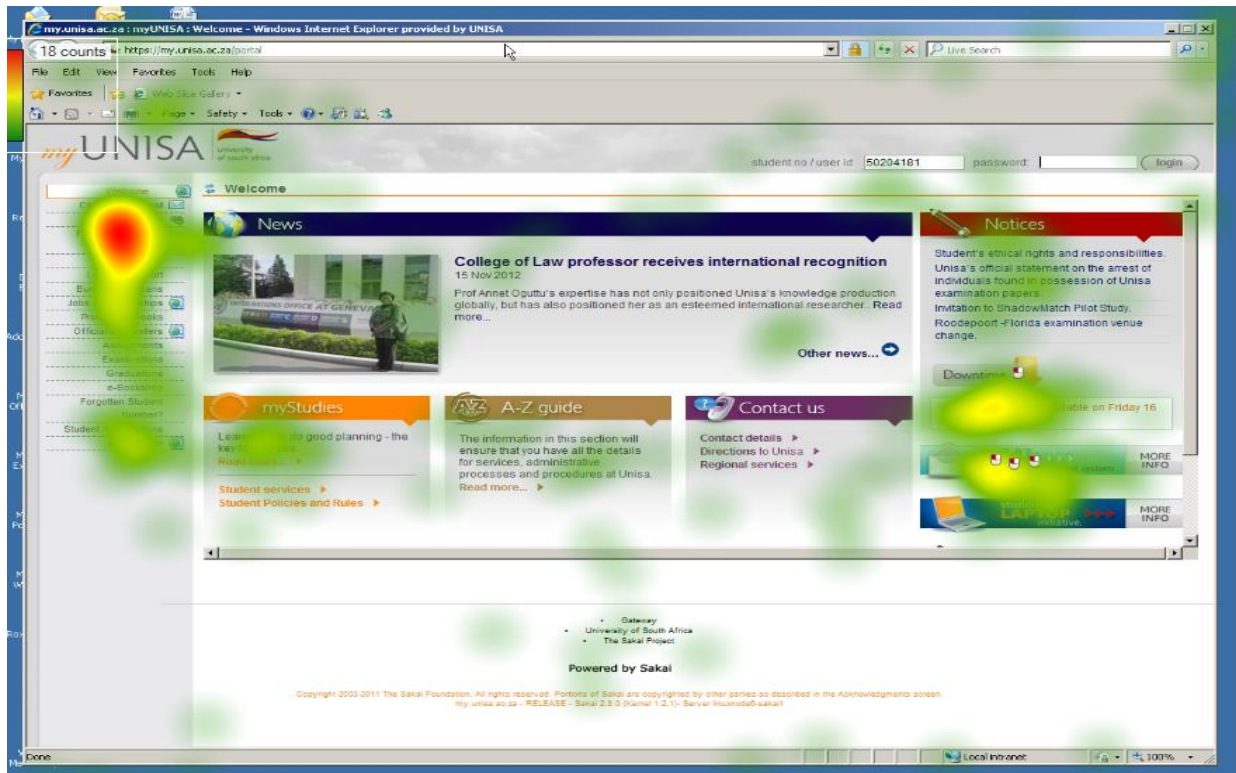


Figure 4.11: Task 1: Combined heat map for Digital Awareness participants - Send e-mail

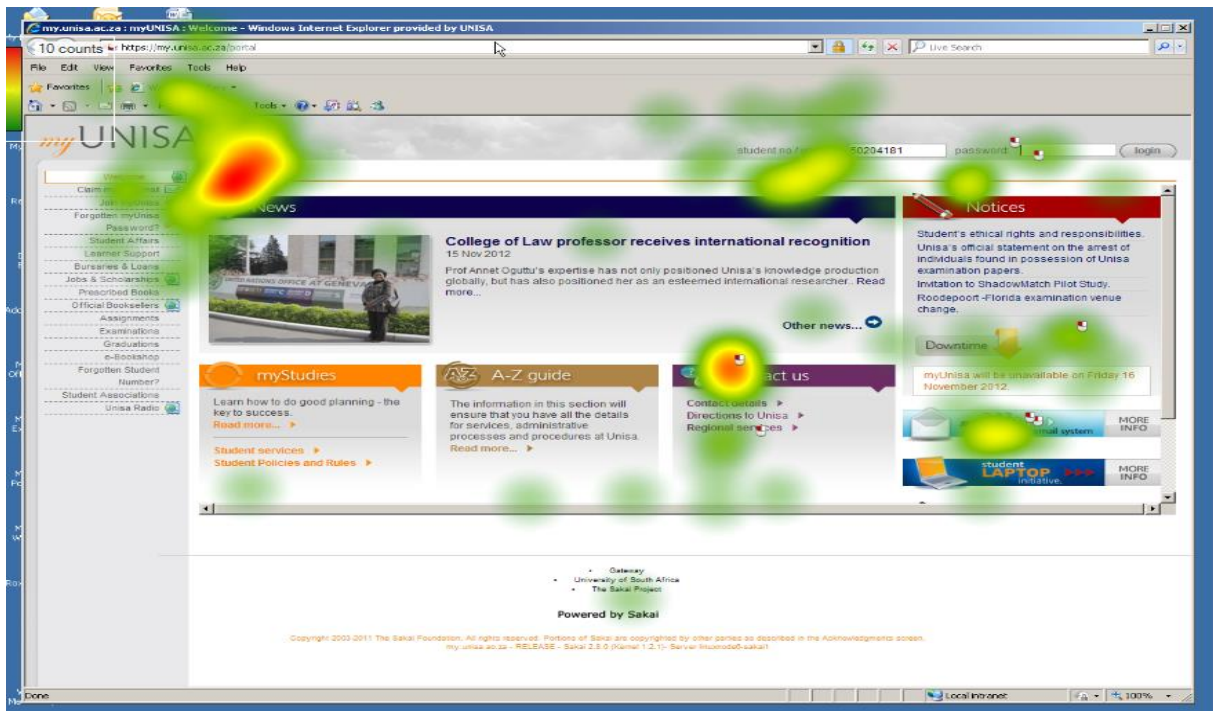


Figure 4.12: Task 1 - Combined heat map for Digital Literacy participants - Send e-mail

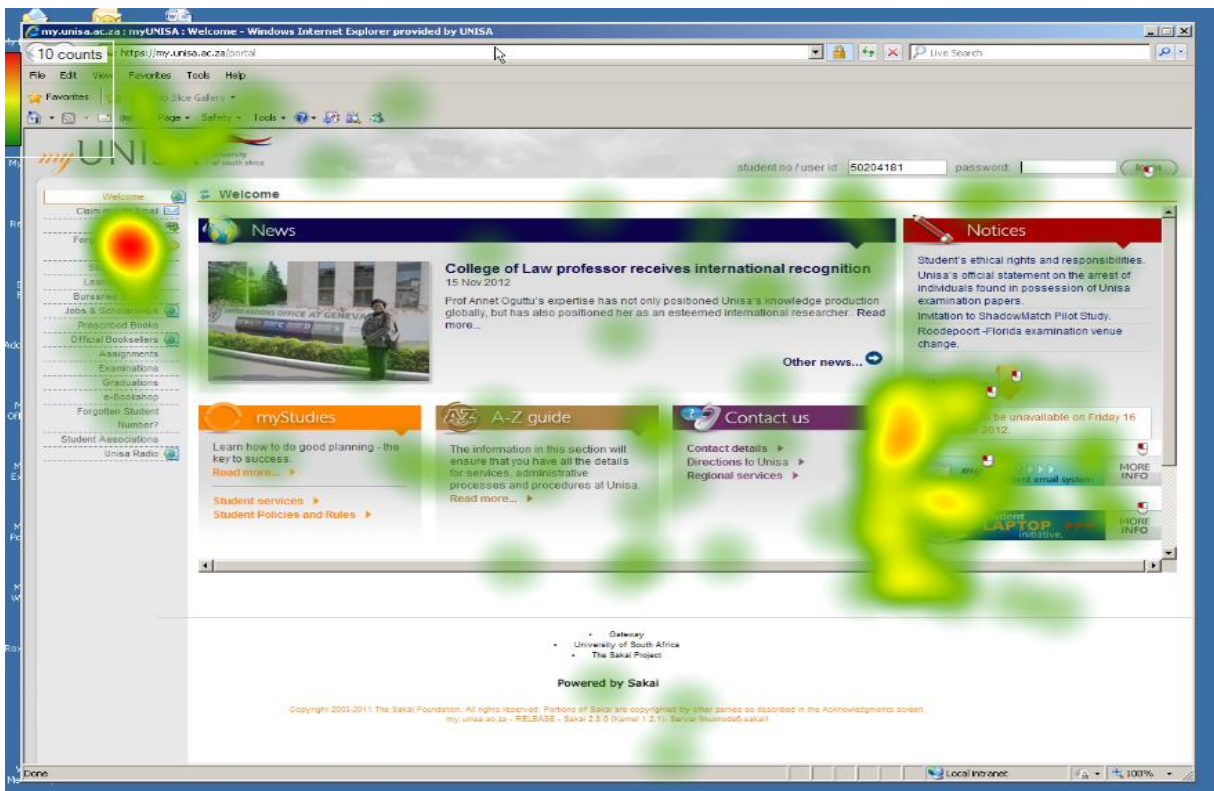


Figure 4.13: Task 1: Combined heat map for Digital Competence participants – Send e-mail

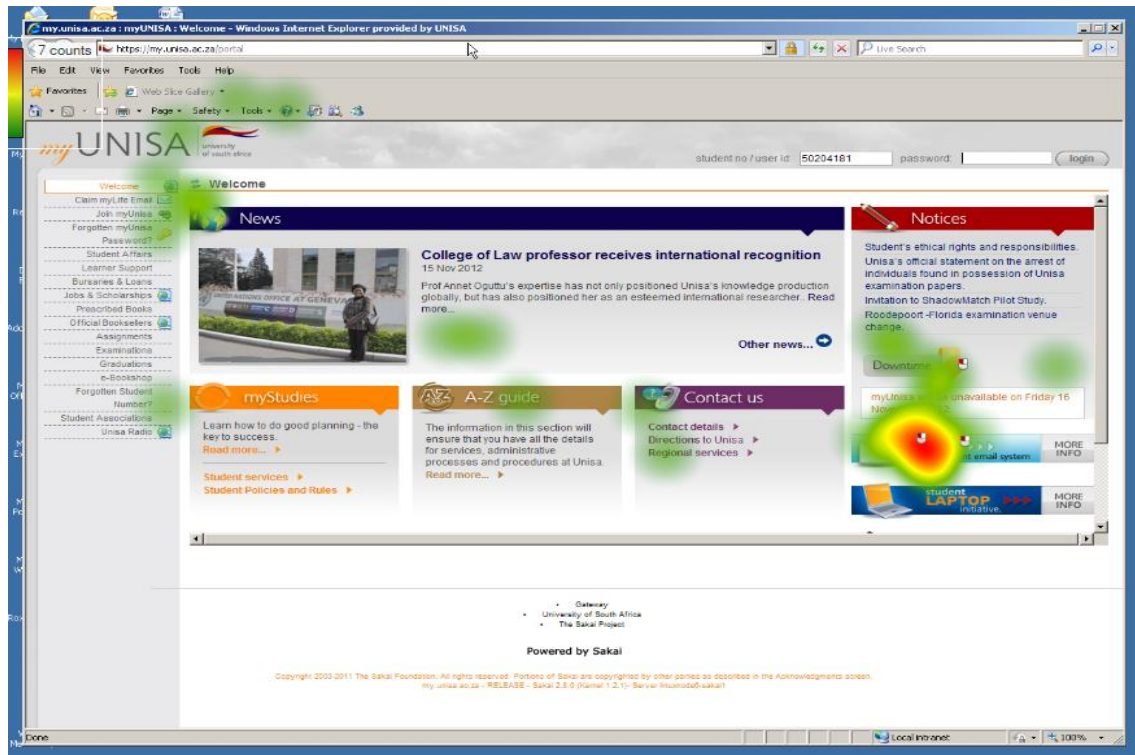


Figure 4.14: Task 1 - Combined heat map for Digital Expertise participants – Send e-mail

Distinct viewing patterns are shown by the preceding heat maps for Task 1, Figures 4.11 to 4.14. These heat maps are well supported by the gaze plots in Figure 4.25 to 4.28 which additionally show the sequence of fixations.

4.5.2.2 Task 2 – Find tutorial letter 101

In Task 2 participants had to find a tutorial letter for a specified module, one of the most common tasks that students are normally expected to perform. This task was completed by all participants as discussed in Section 4.3.4. The area of interest which users needed to select to access the tutorial material is the “Official study material” shown in Figure 4.15.

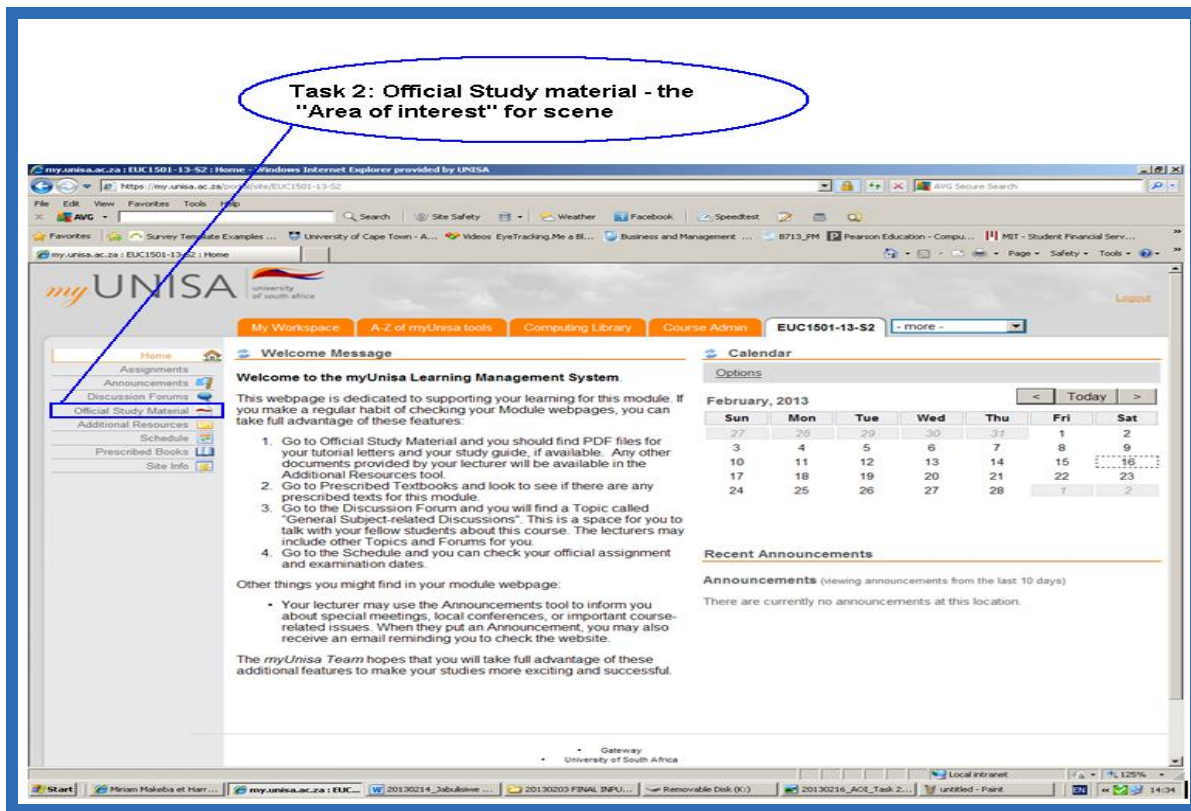


Figure 4.15: Task 2 – Screen layout – Find tutorial letter 101

The heat maps shown in Figure 4.16 to 4.19 indicate similar viewing patterns in all four groups. However, Figure 4.19 shows participants in the Digital Expertise category focused more on the area of interest. Participants in the Digital Competence category (Figure 4.18) focused slightly less on the area of interest but were also notably less distracted from the task than participants in the Digital Literacy (Figure 4.17) and Digital Awareness (Figure 4.16) categories.

The combined heat map for participants in the Digital Literacy category (Figure 4.17) shows that relatively more attention was paid to information on the screen that was irrelevant to the task than in the combined heat maps of other categories, even more than that indicated for participants in the Digital Awareness category (Figure 4.16). Two of the participants in the Digital Literacy category, DL2 and DL3, were particularly slow and performed less efficiently in completing Task 2. This is reflected in the gaze pattern of the combined heat map for the Digital Literacy category (Figure 4.17). As in Task 1, the

combined heat map for participants in the Digital Expertise category (Figure 4.19) focused on task-relevant information.

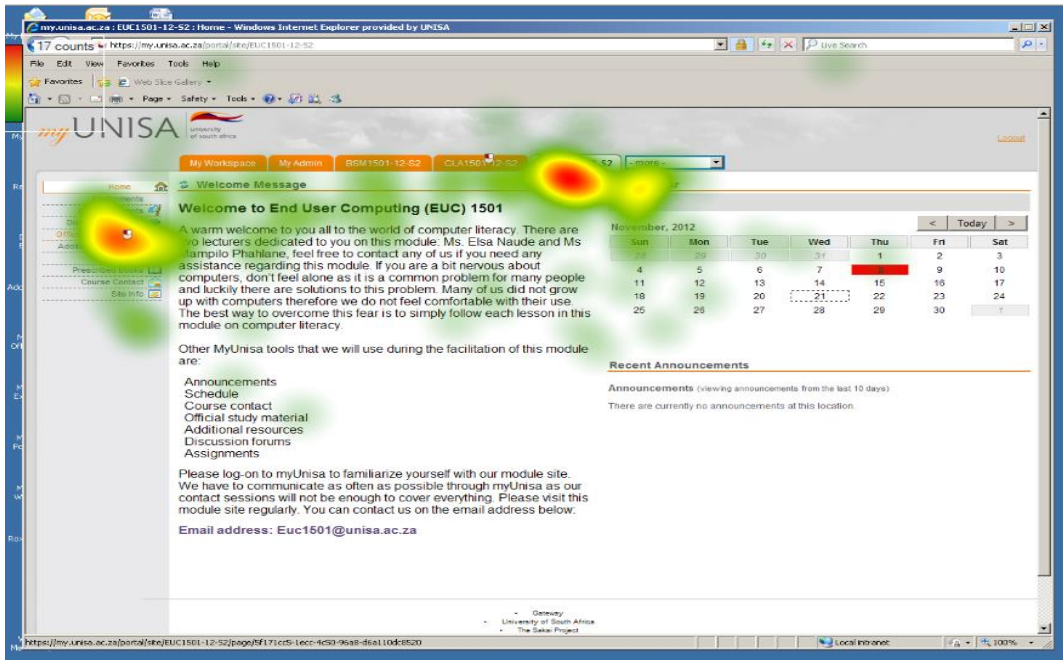


Figure 4.16: Task 2 - Combined heat map for Digital Awareness participants - Find tutorial letter 101

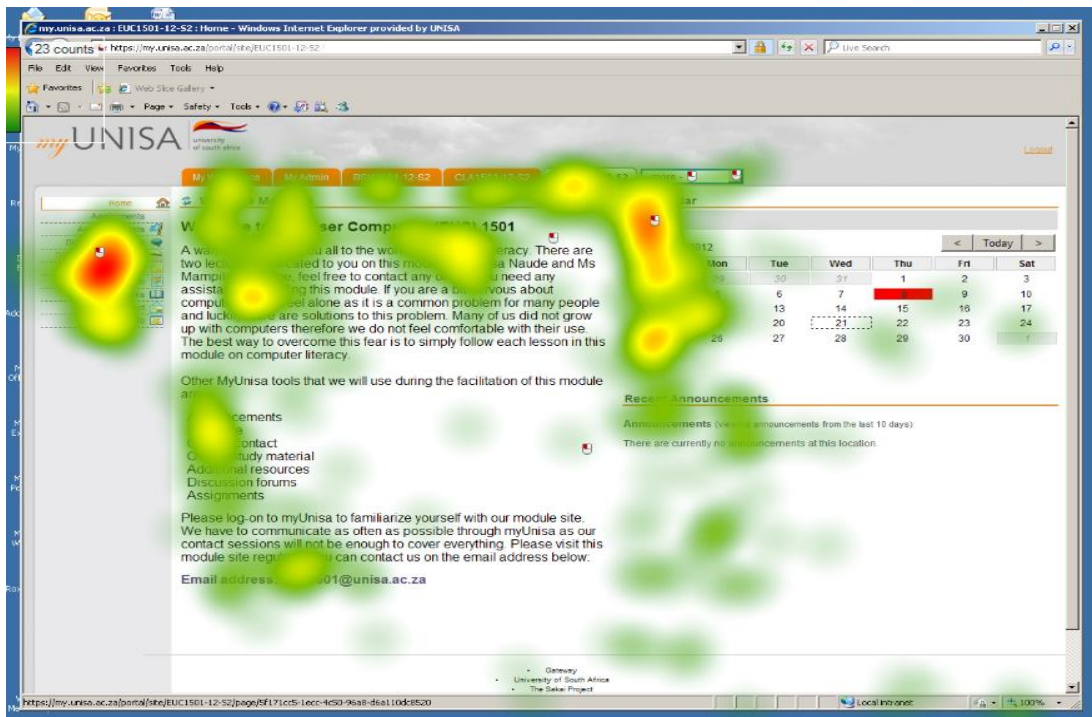


Figure 4.17: Task 2 - Combined heat map for Digital Literacy participants - Find tutorial letter 101

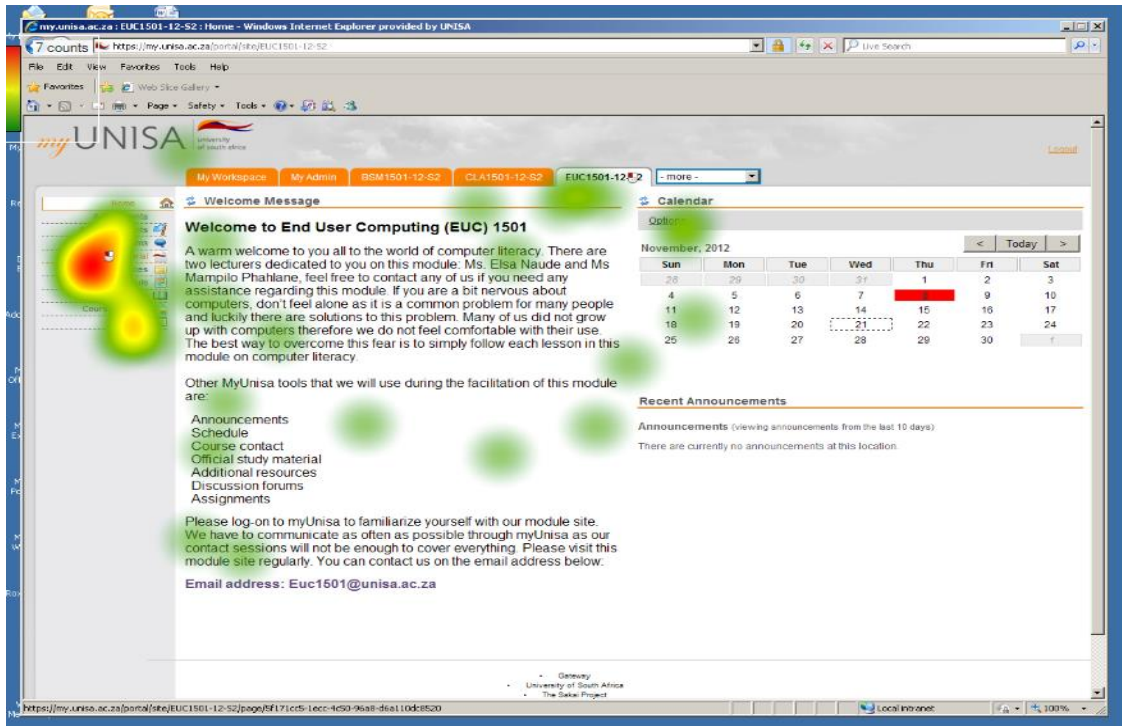


Figure 4.18: Task 2 - Combined heat map for Digital Competence participants - Find tutorial letter 101

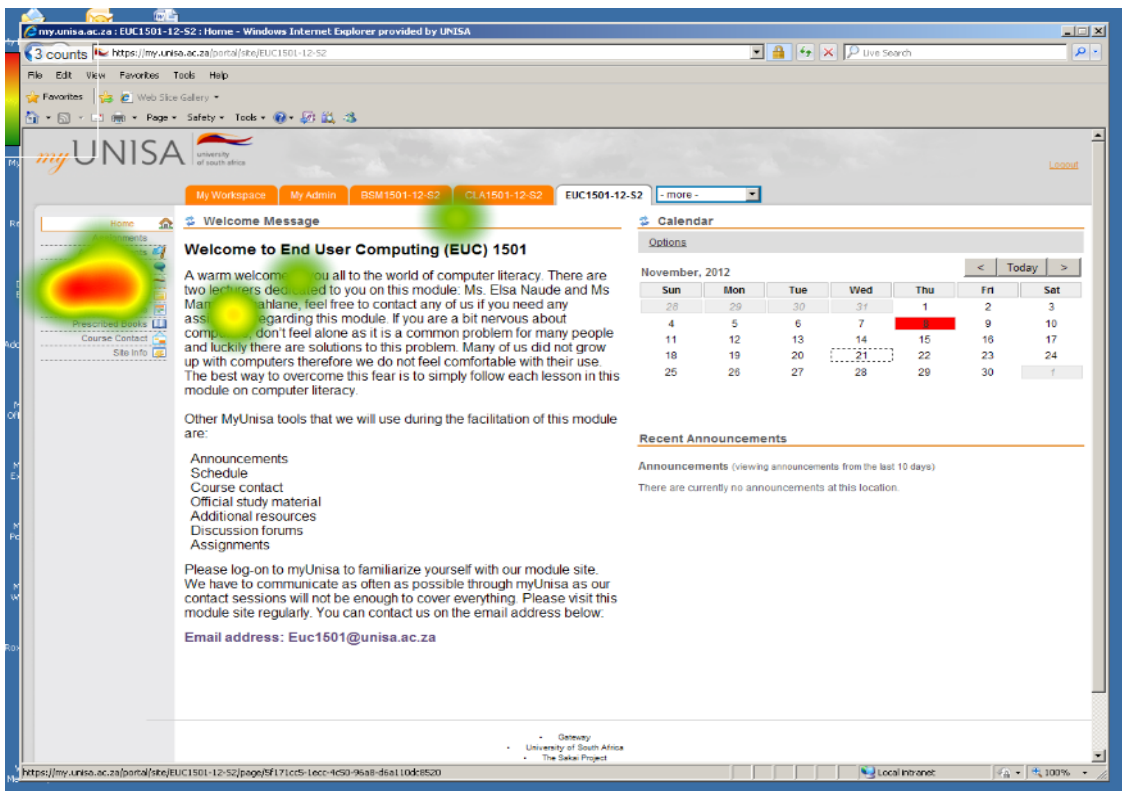


Figure 4.19: Task 2 - Combined heat map for Digital Expertise participants - Find tutorial letter 101

4.5.2.3 Task 3 – Post comment on online discussion forum (ODF)

In Task 3, participants had to post a comment on an on-going discussion on the online discussion forum (ODF). The area of interest which users needed to select to access the ODF is the “Discussion Forums” shown in Figure 4.20.

The heat maps shown in Figures 4.21 to 4.24 show the viewing patterns for participants in different digital proficiency categories. The heat map for participants in the Digital Awareness category, Figure 4.21, is very similar to those for participants in the Digital Expertise and Digital Competence categories shown in Figure 4.24 and 4.23. However it must be noted that most of the participants in the Digital Awareness category required assistance in this task as they pointed out during the discussion of usability problems and amount of assistance required, that they did not know what to do as stated in section 4.3. There is a clear improvement in focus from Digital Literacy to Digital Competence to Digital Expertise. The difference between the Digital Awareness and Digital Literacy heat maps shows that the former group was more focused on the task which is an unexpected result.

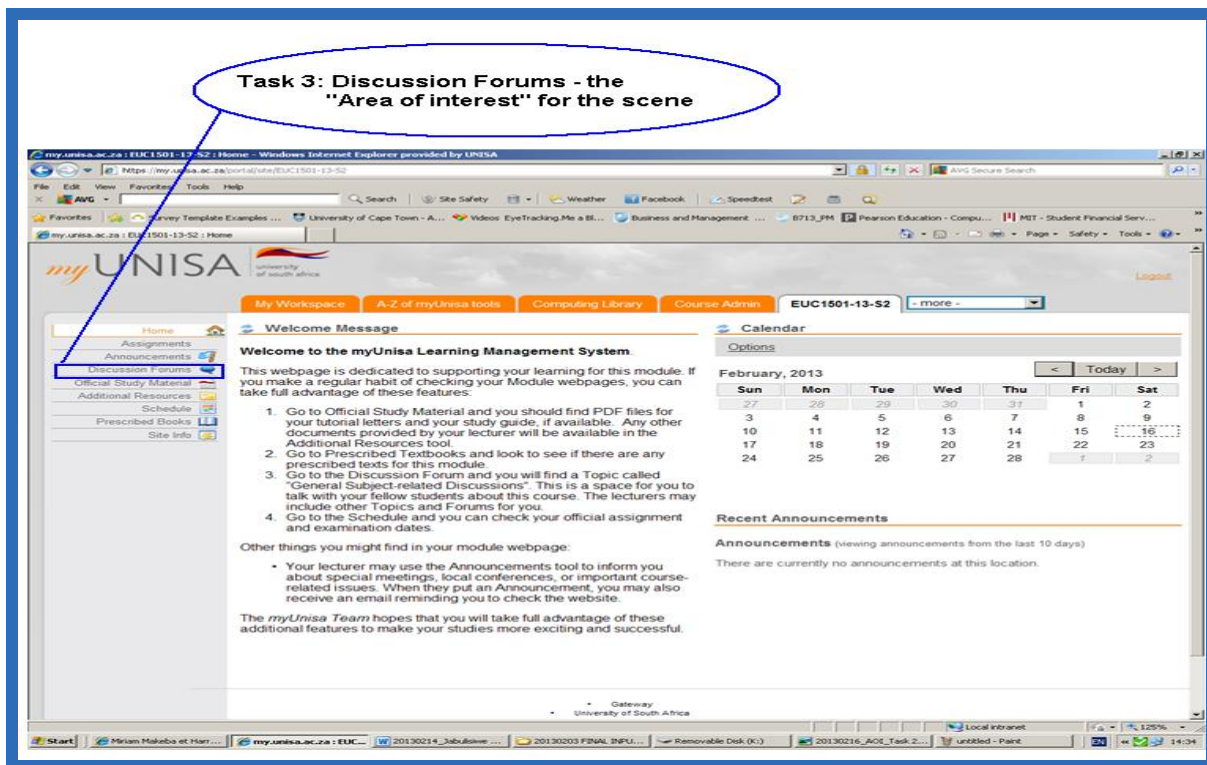


Figure 4.20: Task 3 – Screen layout – Post comment on ODF

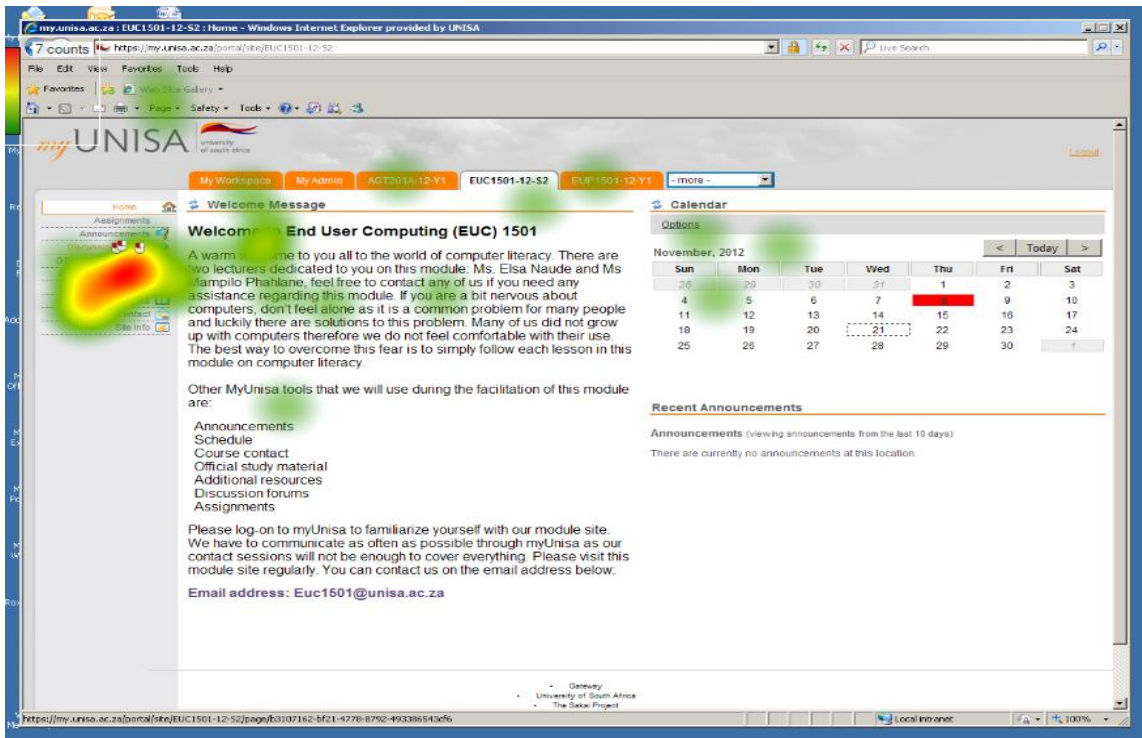


Figure 4.21: Task 3 - Combined heat map for Digital Awareness participants - Post comment on ODF

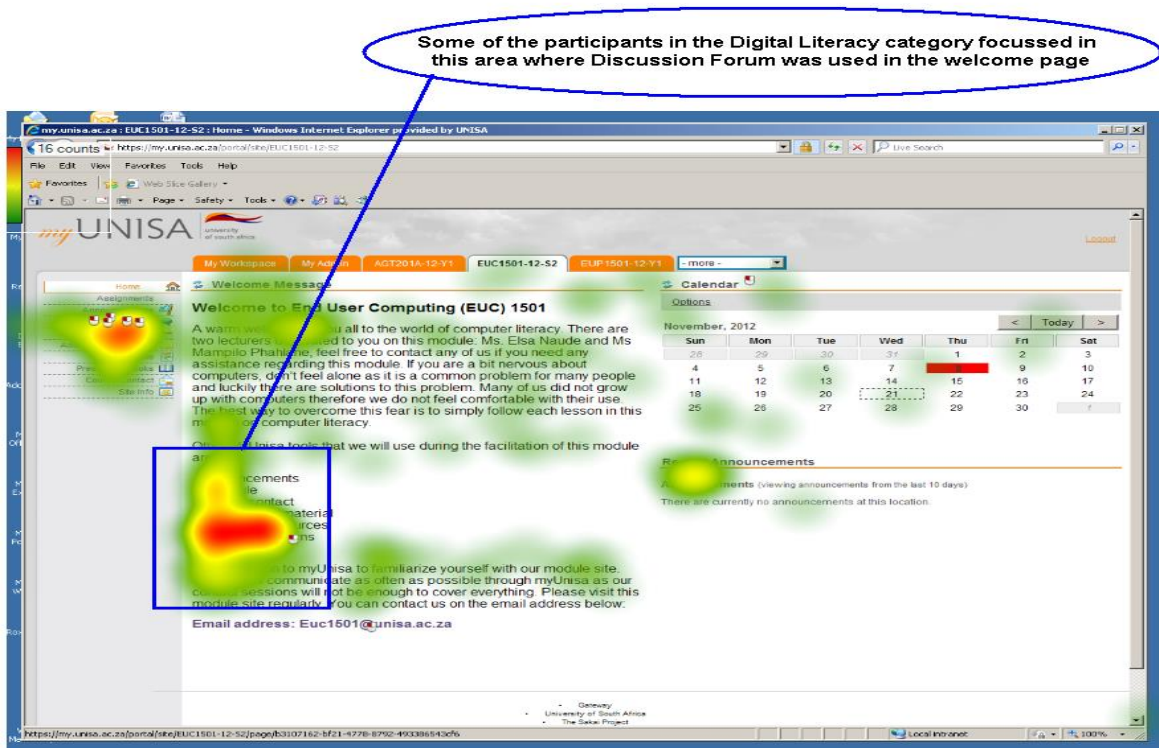


Figure 4.22: Task 3 - Combined heat map for Digital Literacy participants - Post comment on ODF

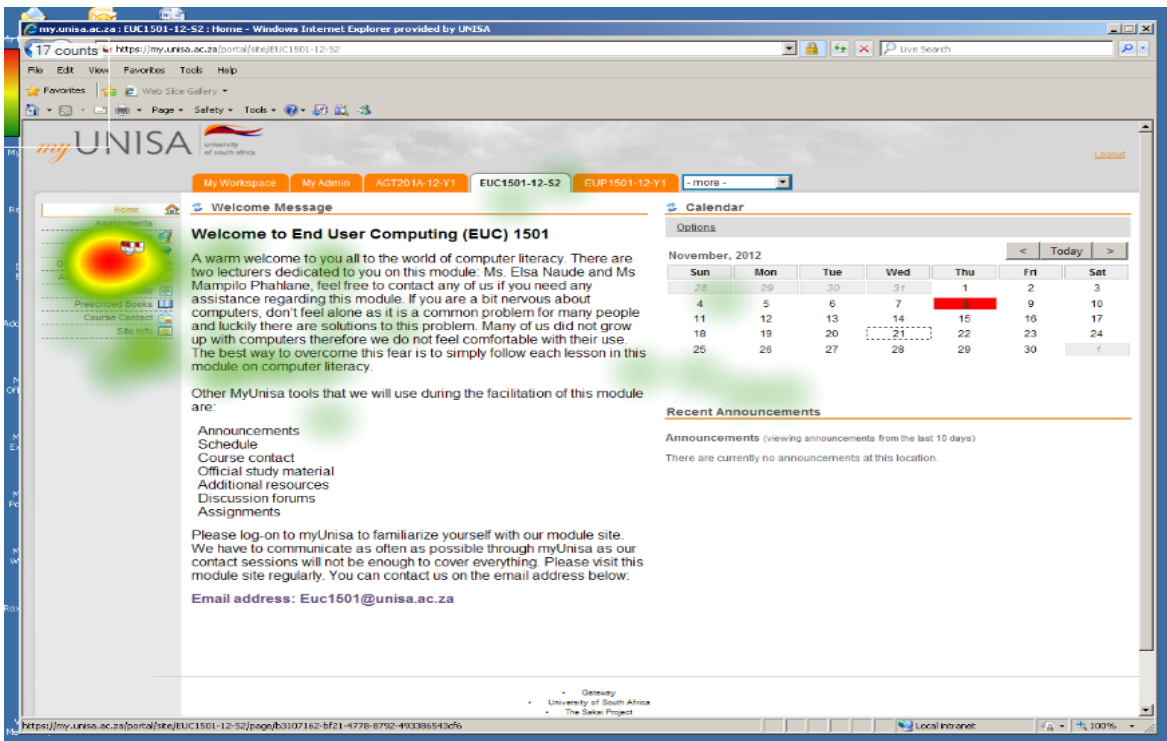


Figure 4.23: Task 3 - Combined heat map for Digital Competence participants - Post comment on ODF

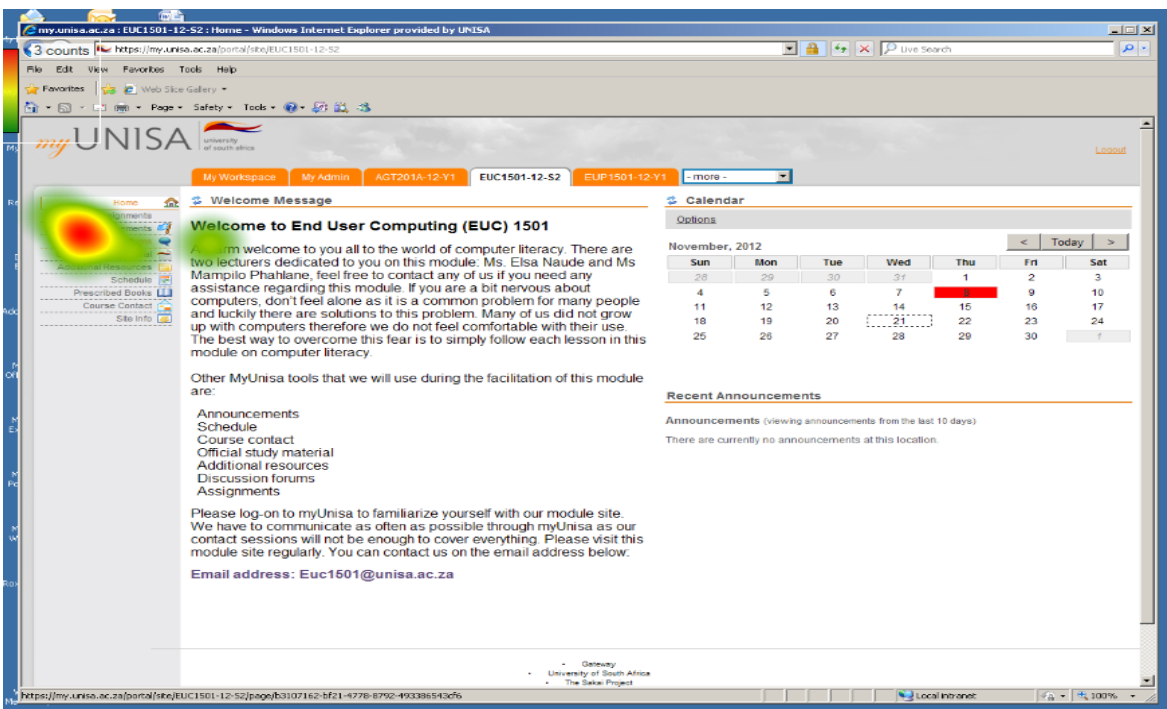


Figure 4.24: Task 3 - Combined heat map for Digital Expertise participants - Post comment on ODF

4.5.2.4 Heat maps – conclusion

In Task 1 users in the Digital Expertise category (Figure 4.14) looked for information in relevant task areas at the bottom right corner where the myLife e-mail icon shown in Figure 4.10 was positioned. In this task the top left corner with information about registering on myUnisa and myLife e-mail, which were not relevant for the task, but attracted the attention of participants in all the other three categories (Figure 4.11 to 4.13). The green and yellow patches in these three categories, the Digital Awareness, Digital Literacy and Digital Competence categories, show the areas of the screen in which participants also searched for the information in order to perform the task.

In Task 2 e-Skill proficient users in the Digital Expertise and Digital Competence categories, Figure 4.18 and Figure 4.19, users looked for information in task-relevant areas at the top left corner where the icon for the official study material shown in Figure 4.15 was positioned. The red coloured area where these users focused are surrounded by more green patches in the Digital Competence category and fewer in the Digital Expertise, and indication that users in the Digital Expertise category were more focused on the correct location. The viewing patterns of the participants in the Digital Awareness (Figure 4.16) and Digital Literacy (Figure 4.17) are similar, with fixations concentrated on the top left corner on the official study material icon. In both combined heat maps an area in the top centre of the screen attracted the participants' attention. The green and yellow patterns formed around the red areas in the heat maps on which participants in the Digital Literacy category looked the most indicate uncertainty. This is unexpectedly more than those observed for participants in the Digital Awareness category.

Similarly in Task 3, more e-Skill proficient users in the Digital Expertise category (Figure 4.24) looked for information in the correct area at the top right corner shown in Figure 4.20. There is more similarity in the combined heat maps for the Digital Competence as well as the Digital awareness categories to that of the Digital expertise category. While participants in the Digital Literacy category also searched information in the correct area on the top left corner in this task, they seem to have been distracted by the words 'Discussion forum' used in the text (Figure 4.22).

The performance of participants in the three tasks varied, with an overall better performance in Task 2. As Gegenfurtner et al (2011) observe, tasks differ as a function of their complexity and contextual demands (Gegenfurtner, Lehtinen & Säljö, 2011). This variation in performance in the three tasks is therefore expected. The usability results also showed that less e-Skill proficient participants in the Digital Awareness and Digital Literacy categories required more assistance in finding relevant information and performing the tasks.

The consistently higher efficiency and speed by which participants in the Digital Expertise category performed in all three tasks aligns to the definition of expertise, where an expert performance is defined as the consistently superior performance on a specified set of representative tasks for a domain (Gegenfurtner et al., 2011). This is in line with observations made in similar studies, in which it was observed that expert users consistently performed better in tasks than novice users (De Kock et al., 2009). Efficiency and effectiveness, as discussed in section 2.2.2, are measures of usability. The following section discusses the gaze plots, and provides further visual evidence of the differences in performance in the three tasks of participants in different digital proficiency categories.

4.5.3 Gaze plots

Eye tracking data collected during the performance of the tasks also included gaze plots (discussed in section 2.2.6). A gaze plot shows the participant's scan path and fixations recorded while the user completes a task (Nielsen et al, 2009; Poole & Ball, 2006). The gaze plots shown in this section provide data collected during eye tracking as participants performed the tasks in the HCI lab. Each of the three tasks is discussed using combined gaze plots for participants in each digital proficiency category. In cases where gaze plots for individual participants are used for illustration, this is explicitly stated.

4.5.3.1 Task 1 – Send an e-mail

The screen layout for the scene under discussion for this task is as shown earlier (Figure 4.10). In this task, as earlier stated in section 4.6.2.1, users were required to send an e-mail with an attachment to a specified e-mail address. Figure 4.25 to 4.28 show combined

gaze plots for participants in each digital proficiency category for the scene under discussion. On each gaze plot, the different coloured circles and lines represent different participants.

The scan paths for participants in the Digital Awareness and Digital Literacy categories were longer and had more fixations that were dispersed across the screen. In comparison, scan paths of participants in the Digital Competence and Digital Expertise categories were shorter and had fewer fixations. This was more pronounced for the Digital Expertise category. Shorter scan paths with fewer fixations in the gaze plots show a more efficient search while larger numbers of fixations and longer scan paths indicate a less efficient search or uncertainty (Calitz et al., 2009).

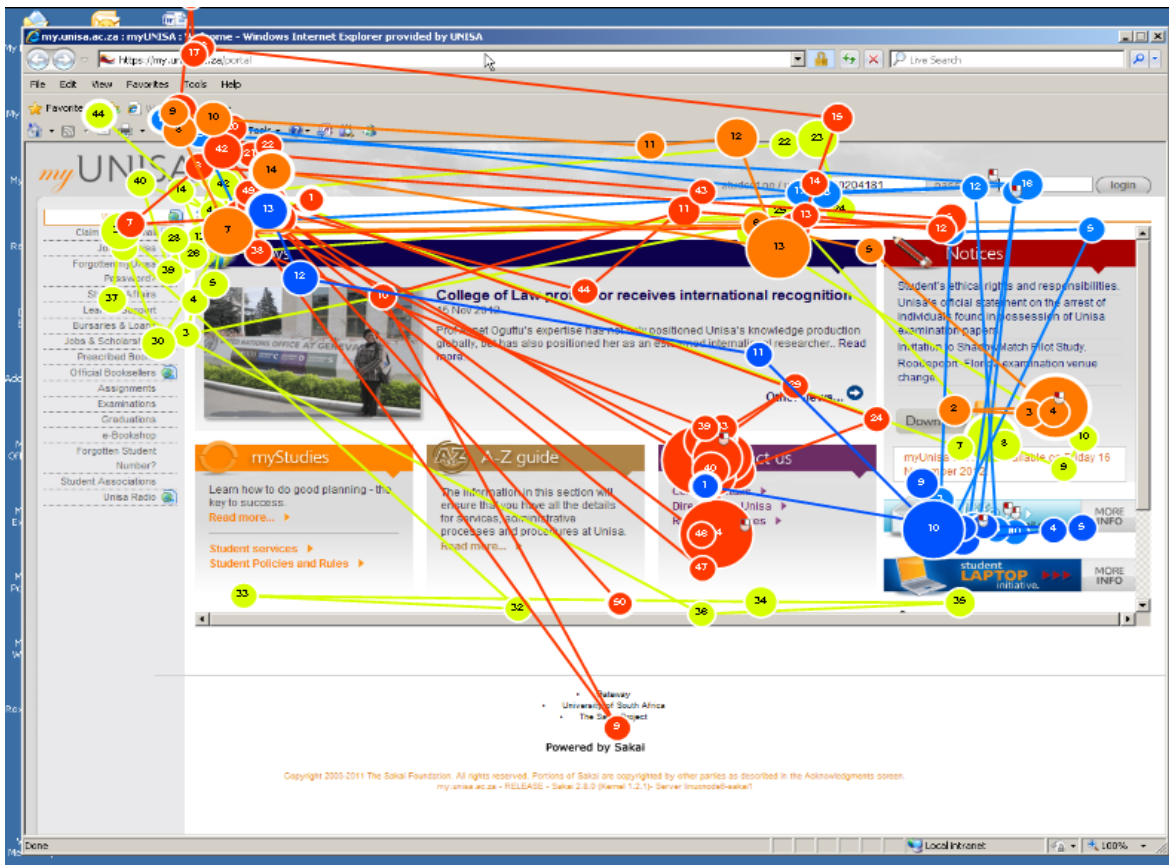


Figure 4.25: Task 1 - Combined Gaze plot - Digital Awareness category – Send e-mail

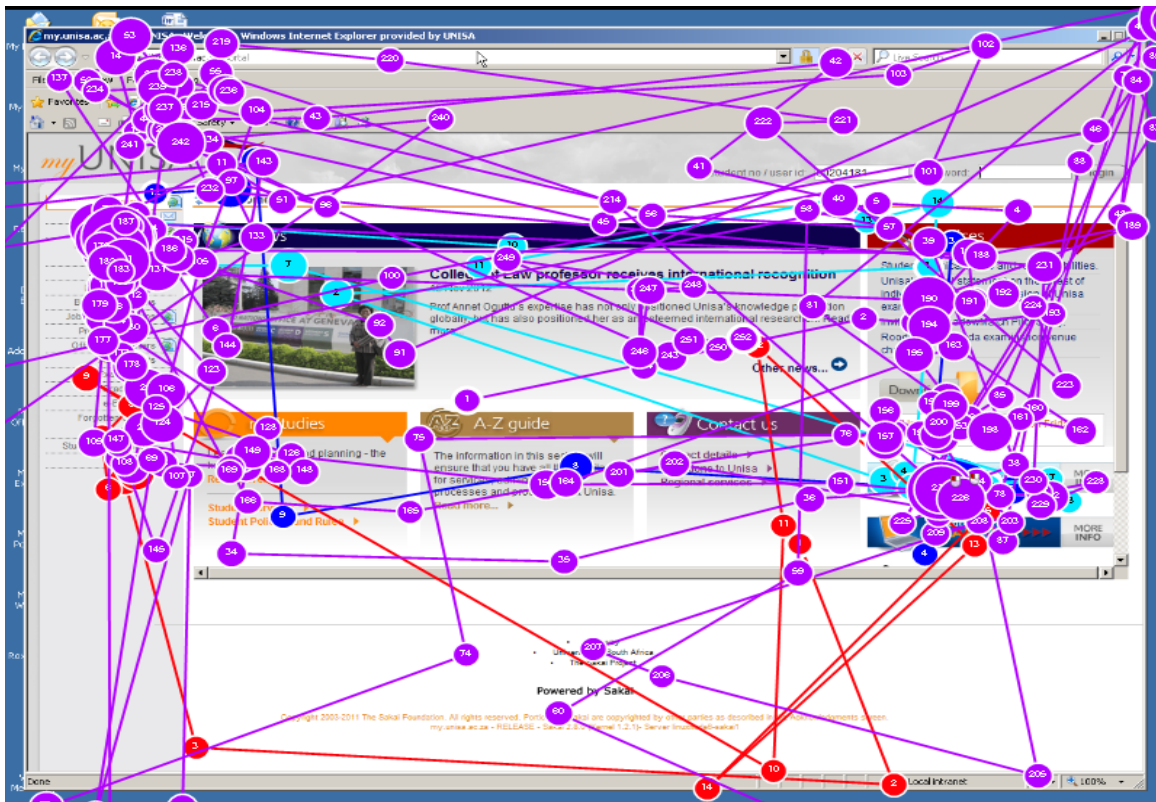


Figure 4.26: Task 1 - Combined Gaze plot - Digital Literacy category – Send e-mail

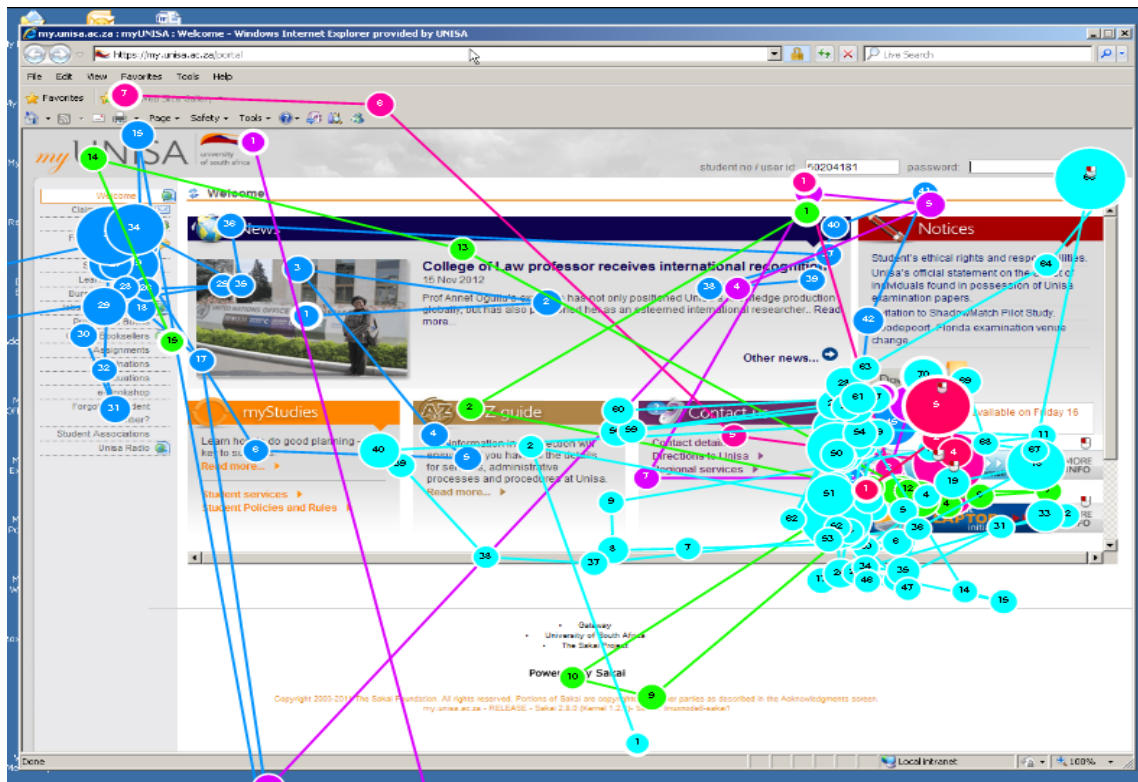


Figure 4.27: Task 1 - Combined Gaze plot - Digital Competence category – Send e-mail

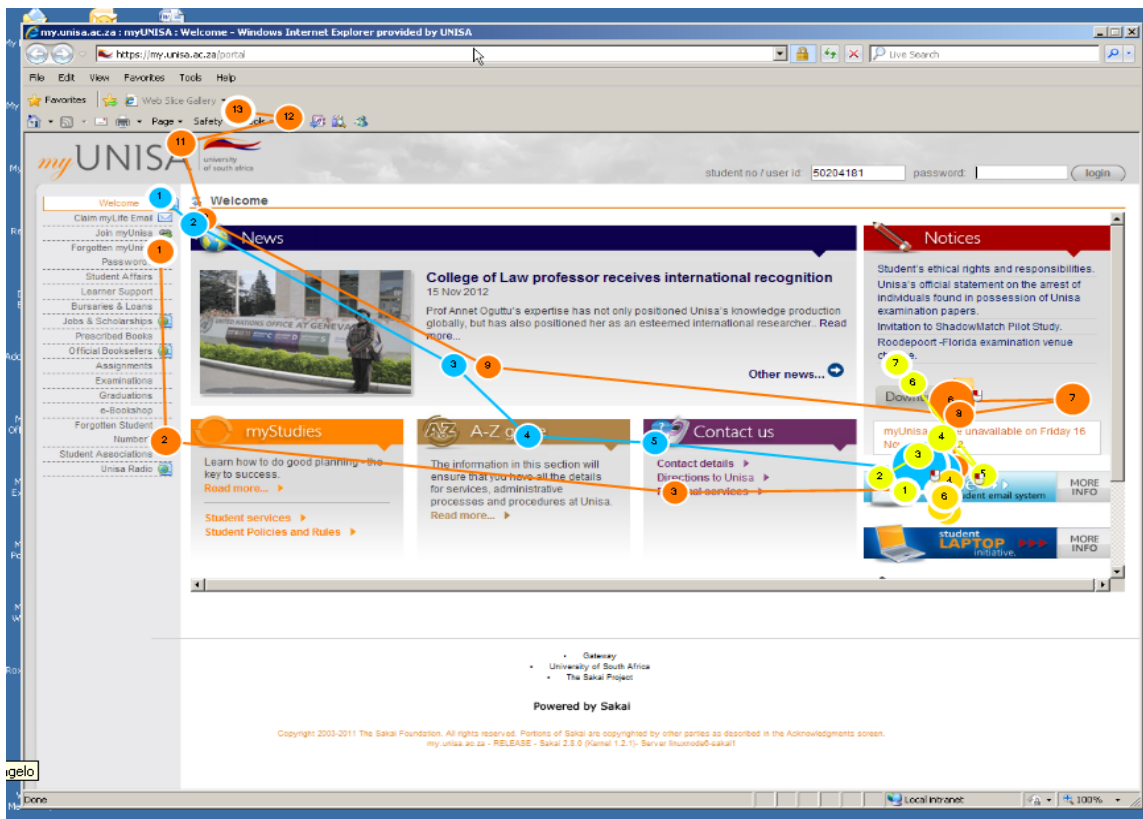


Figure 4.28: Task 1 - Combined gaze plot for Digital Expertise category - Send e-mail

4.5.3.2 Illustration: Participant DA1 and DE4

The following illustration shows the eye tracking results showing gaze plots for two of the participants while performing Task 1. Participants DA1 in the Digital Awareness category Figure 4.29 and DE4 in the Digital Expertise category Figure 4.30 show the results in the combined heat maps (Figure 4.25 to 4.28). Although this illustration shows the sequence of the fixations of the viewing patterns of the two participants, the combined heat maps of all participants per digital proficiency level progressively demonstrate similar viewing patterns from Digital Awareness to Digital Expertise. The Digital Expertise participants fixated more on the area of interest for this scene which was the e-mail icon, than any of the other groups.

Participant DA1:

Figure 4.29 shows the gaze plot for a participant in the Digital Awareness category when performing Task 1, as the participant attempted to locate the myLife e-mail system icon. This is distinctly different from that of Figure 4.30 where the participant in the Digital Expertise category was performing the same task. The sequence of the fixations is indicated by the order of the numbers that label the fixations. The scan path shows a more efficient viewing pattern of the screen for participant DE4 (Figure 4.30), indicating how the participant navigated the page. Conversely, participant DA1 did not fixate at all on the myLife e-mail icon. The concentration of the fixations on the left corner shows that the participant was looking at the options to claim myLife e-mail and to join myUnisa which drew the participant's attention. The participant, DA1, took 10 minutes attempting to perform the task, and did not even complete the task.

Participant DE4

Figure 4.30 shows the gaze plot for participant DE4 for Task 1. Although the entry point was the top left corner of the screen, the participant fixated on the myLife e-mail icon. The concentration of the fixations on the bottom right corner shows that the participant was focused on the myLife e-mail system icon. This participant took only 4 minutes to perform the task and completed it, as compared to participant DA1 who took 10 minutes and did not complete the task.

The sequence of the fixations in these 2 gaze plots (4.29 and Figure 4.30) clearly demonstrates the differences in the viewing patterns. E-Skill proficient users in the Digital Expertise category all had fewer fixations on task relevant areas. Although the scan paths for participants in the Digital Competence category were longer their pattern emulated the gaze pattern of the participants in the Digital Expertise category. The combined gaze plot for participants in the Digital Awareness and Digital Literacy categories had longer scan paths and more fixations dispersed throughout the screen. In the Digital Awareness category fixations were concentrated on the upper left corner, which correlates to the heat

map in Figure 4.12.



Figure 4.29: Task 1 - Send e-mail - Gaze plot for Participant DA1

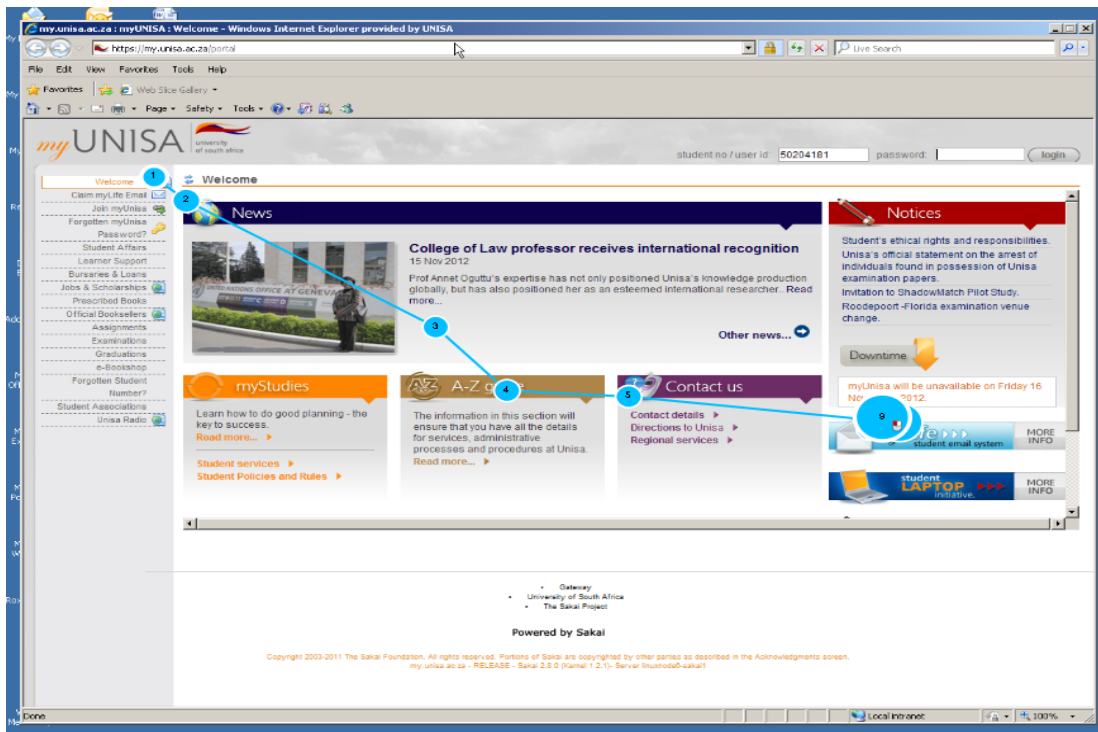


Figure 4.30: Task 1 - Send e-mail - Gaze plot for Participant DE4

Within the two categories, Digital Awareness and Digital Literacy, some variations in the gaze patterns among participants were observed. In the Digital Awareness category participant DA4 had shorter scan paths and fewer fixations. This indicates a more efficient search. This is supported by the time of six (6) minutes that the participant took to complete the task, compared to an average of four (4) minutes for participants in the Digital Expertise category. In the Digital Literacy category some variations within the category, shows that, for example, participant DL2 had much longer scan paths. This participant also took the longest time while attempting to perform the task and was unsuccessful.

4.5.3.3 Task 2 – Find tutorial letter 101

The screen layout for the scene under discussion for Task 2 is as shown earlier (Figure 4.15). In this task, as stated in section 4.6.2.2, users were required to find tutorial letter 101. Figure 4.31 to 4.34 show combined gaze plots for participants in each digital proficiency category for the scene under discussion. The viewing patterns observed were similar to those in Task 1. The scan paths for participants in the Digital Awareness and Digital Literacy categories were longer and had more fixations that were dispersed across the screen. The fixation patterns for participants in the Digital Literacy category were more scattered on the screen, even more than for the Digital Awareness category.

Two of the participants in the Digital Literacy category, DL2 and DL3, demonstrated a more random search strategy, shown by longer scan paths and more fixations dispersed throughout the screen, an indication of an inefficient search strategy and uncertainty (Red and light blue gaze plots respectively, in Figure 4.32). Information gathered through interviews and observations, an aspect of triangulation, revealed that participant DL2 works and studies part-time, and uses the LMS infrequently. The scan paths of participants in the Digital Competence category were shorter than those in the Digital Awareness and Digital Literacy categories. The scan paths for the Digital expertise category were shorter and had fewer fixations.

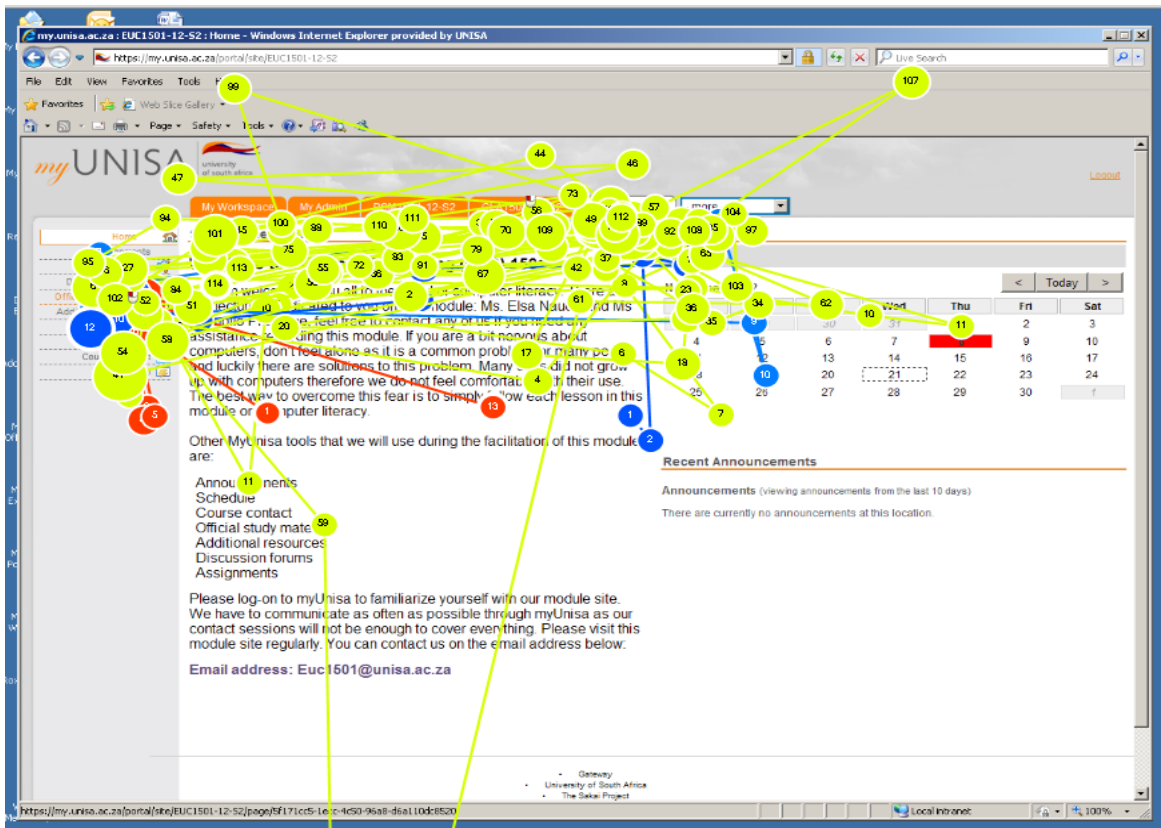


Figure 4.31: Task 2 - Combined gaze plot for Digital Awareness category – Find Tutorial letter 101

The efficiency of the viewing patterns therefore differs between categories, and among participants. The following illustration demonstrates this.

4.5.3.4 Illustration: Participant L2

Participant DL2 (represented by RED circles in Figure 4.32)

Although Task 2 was completed quicker and participants found it easier, Participant DL2, however, had difficulty with this task. The participant's viewing pattern shows a larger numbers of fixations and longer scan paths across the screen which indicates an inefficient search (The participant reported infrequent use of the LMS due to work commitments). The amount of time that participant DL2 spent on this task was 4 minutes, the highest in the category and the same as for participant DA1 in the Digital Awareness category. This is 4 times higher than the time spent by participants in the Digital Competence and Digital Expertise categories (Table 4.13).

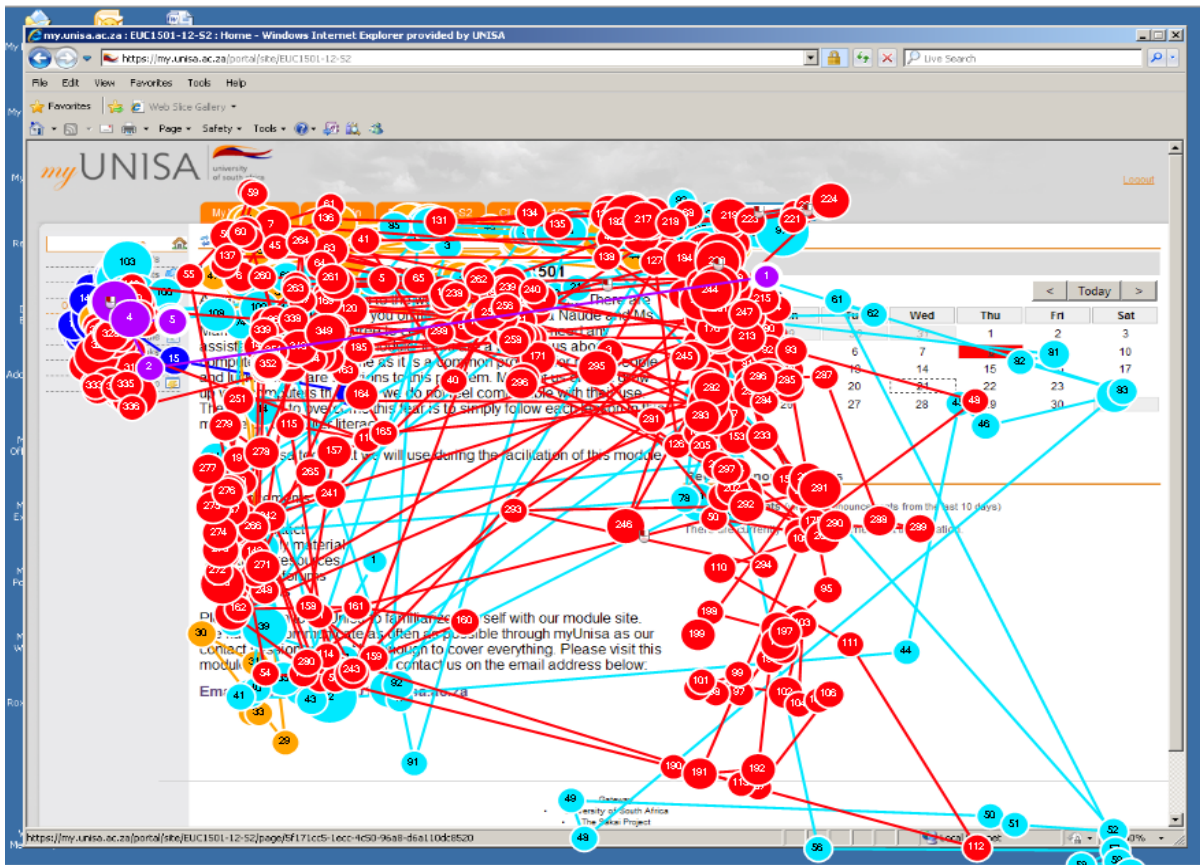


Figure 4.32: Task 2 - Combined gaze plot for Digital Literacy category – Find Tutorial letter 101 (Participant DL2 represented by red circles)

In Task 2, as in Task 1, participants in the Digital Expertise category (Figure 4.34) were focused on the area of interest, the “Official Study material” icon on the top left corner. There were similarities in the gaze patterns of participants in the Digital Competence category (Figure 4.33) to those observed in the gaze plot for the Digital expertise category. There were some fixations close to the area of interest, but these were fewer than in the gaze plots for the Digital Awareness (Figure 4.31) and Digital Literacy (Figure 4.32) categories.

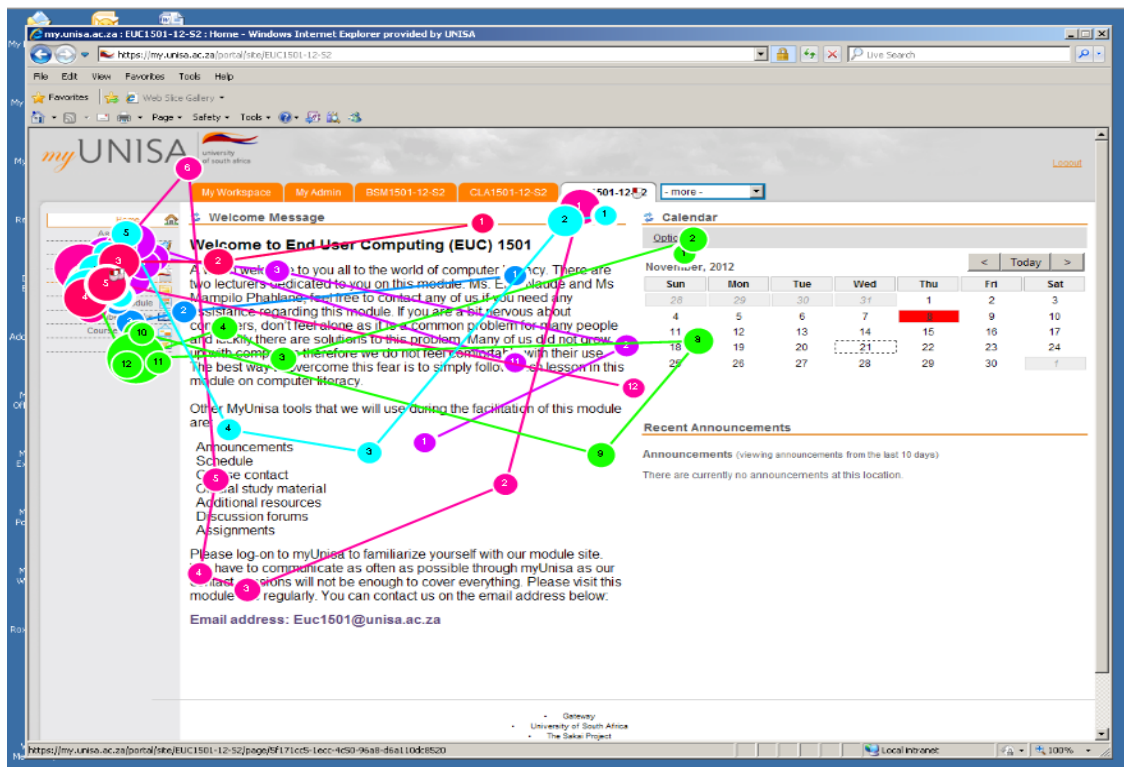


Figure 4.33: Task 2 - Combined gaze plot for Digital Competence category – Find Tutorial letter 101

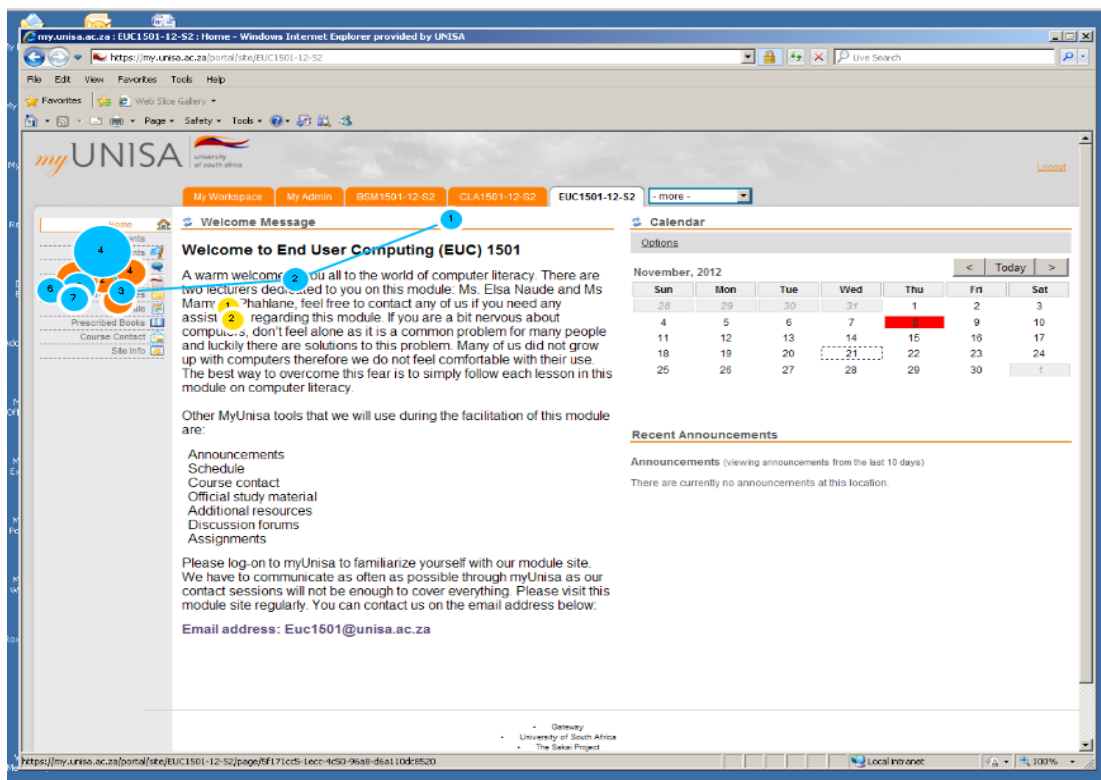


Figure 4.34: Task 2 - Combined gaze plot for Digital Expertise category – Find Tutorial letter 101

4.5.3.5 Task 3 – Post comment on online discussion forum (ODF)

The screen layout for the scene under discussion for Task 3 is as shown earlier in Figure 4.20. In this task, as stated in section 4.6.2.3, users were required to post a comment to an on-going discussion on the online discussion forum (ODF) of the specified module. Figure 4.35 to 4.38 show combined gaze plots for participants in each digital proficiency category for the scene under discussion.

As in previous tasks, e-Skill proficient users performed better in this task. The participants in the Digital Expertise category (Figure 4.38) had fewer fixations on task-relevant areas than participants in the other categories. The scan paths for participants in the Digital Competence category were similar to those of the Digital Expertise category, and interestingly those of the Digital Awareness category as well, even though some fixations were slightly outside the area of interest. There were more fixations of participants in the Digital Literacy category that were on task-redundant areas. Of particular note is participant DL4, represented by the brown gaze plot in Figure 4.36 had longest scan paths and most fixations.

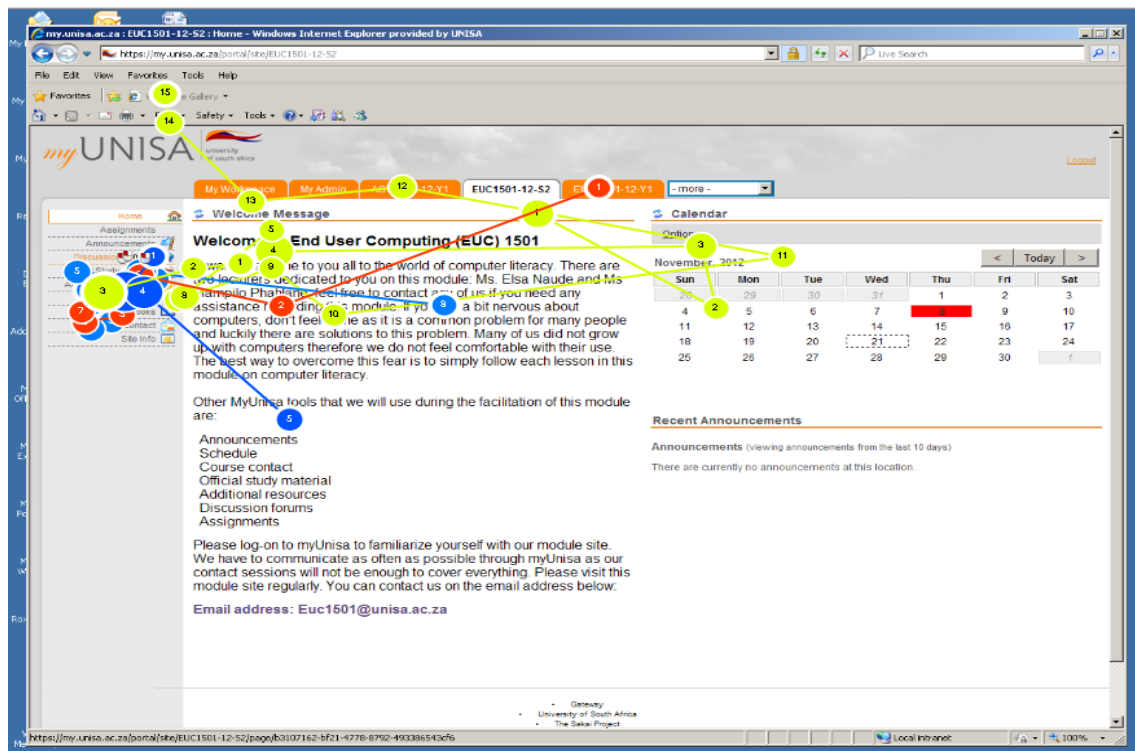


Figure 4.35: Task 3 - Combined gaze plot for Digital Awareness category – Post comment on ODF

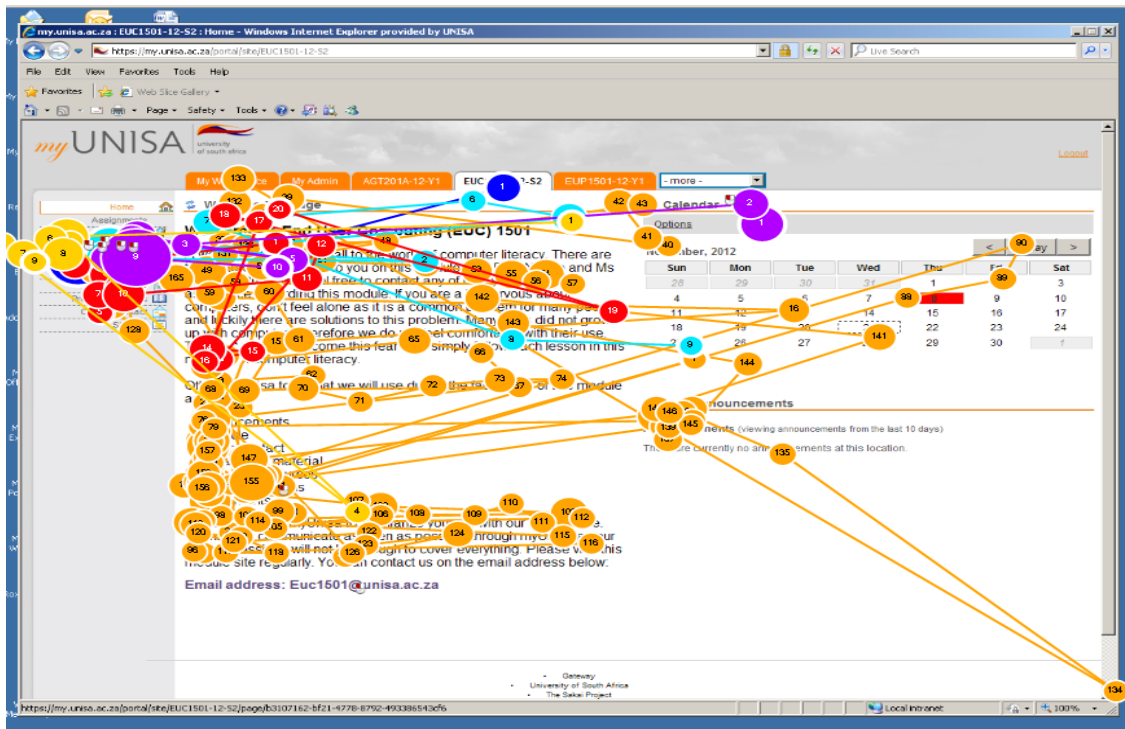


Figure 4.36: Task 3 - Combined gaze plot for Digital Literacy category – Post comment on ODF

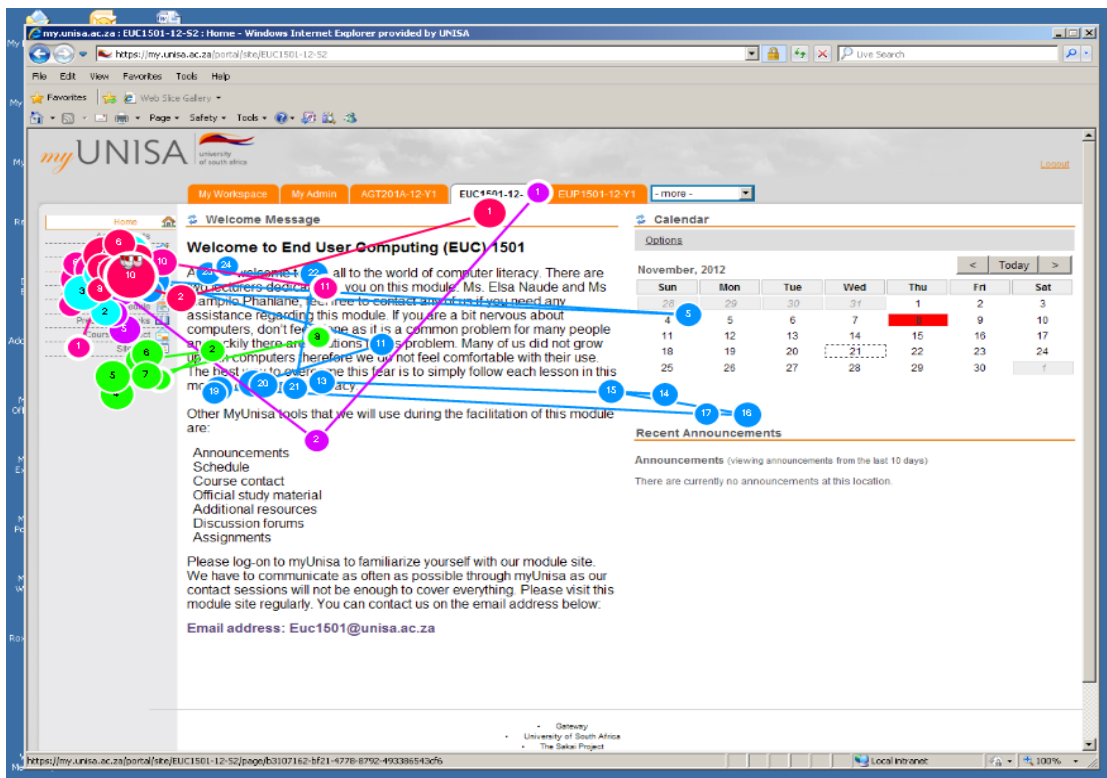


Figure 4.37: Task 3 - Combined gaze plot for Digital Competence category – Post comment on ODF

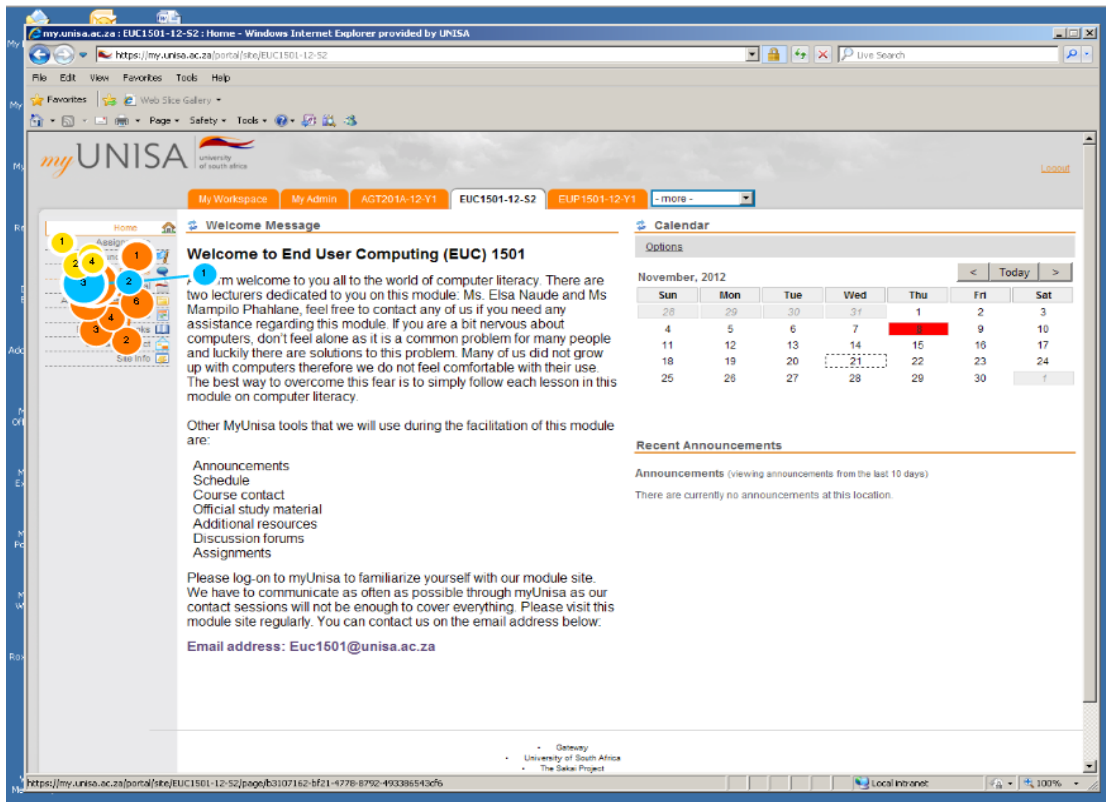


Figure 4.38: Task 3 - Combined gaze plot for Digital Expertise category – Post comment on ODF

These observations are in line with other research findings which also identified differences between users who are less e-Skill proficient than those who are more proficient (Popovic, 2007; Pretorius et al., 2010). Expertise is characterised by selective attention allocation and focus on task-relevant information (Popovic, 2007).

4.5.3.6 Gaze plots - conclusion

In all three tasks, longer scan paths, and relatively more fixations were recorded for the combined gaze plots of users in the Digital Awareness, Digital Literacy and Digital Competence categories than participants in the Digital Expertise category. The fixations of gaze plots of the more proficient users were fewer and concentrated on task relevant areas. The scan paths for participants in the Digital Competence category were longer, but exhibited some similar pattern with the gaze pattern of gaze plots for participants in the Digital Expertise category. The gaze plots for participants in the Digital Awareness and

Digital Literacy categories had longer scan paths and more fixations dispersed throughout the screen.

In Task 1, participants in the Digital Awareness, Digital Literacy and Digital Competence categories demonstrated more intense attention to the option to register on myUnisa on the upper left corner, and less focus on the myLife e-mail icon at the bottom right of the screen. More searching on the Webpage and uncertainty was shown by participants in the Digital Awareness and Digital Literacy categories. On the contrary, shorter scan paths and fewer fixations were observed for the combined gaze plots of participants in the Expertise category. The combined gaze plots for Tasks 2 and 3 show a similar pattern. As the level of e-Skills increased there were fewer fixations, and shorter scan paths, depicting more efficient use of the LMS.

The illustrations of the individual gaze patterns for the two users DA1 and DE4 in Task 1 show that participant DE4 had more fixations on the task-relevant area, the myLife e-mail icon, while participant DA1 did not fixate on the area of interest. Differences in perceptual and decision-making strategies account for variation in observed gaze patterns. Related research has shown that because of experts' superior speed in information processing and higher levels of confidence, experts tend to spend less time on task completion than novices (Gegenfurtner et al., 2011).

The combined gaze plots show that participants in the Digital Expertise category had fewer fixations, and that these were on task-relevant areas. The scan paths for participants in the Digital Awareness and Digital Literacy categories were longer and randomly dispersed on the Webpage. Differences were observed within the categories as illustrated using participant DL2 in Task 2 (Figure 4.32). Task 2 was performed better than all the tasks in all digital proficiency categories however some participants, like participant DL2, showed a more random search strategy, with more fixations on task-redundant areas of the Webpage.

The following section describes the results of the user satisfaction questionnaire completed by each of the users at the end of the sessions.

4.6 Post-test questionnaire – User satisfaction

There is consensus that satisfaction can be considered to be a broad representative of the overall evaluative of a product, an experience, or a phenomenon, and involves an expression or judgment of one's feelings and attitudes towards a variety of factors affecting the situation to be judged (Lindgaard, 2009; Teerling & Huizingh, 2004). As discussed in section 2.2, satisfaction is a component of usability. A post-test user satisfaction questionnaire was completed by participants after performing the tasks at the HCI lab. The 5-point Likert scale used in the questionnaire measured users' perception of the usability of the LMS, specifically, the ease of use, efficiency, effectiveness, ease with which system can be remembered, and the satisfaction with the way the LMS works. The five-point Likert scale, used "1" to represent "Not good at all", and "5" to represent "Very good" (Appendix 3). Questionnaires designed to assess aspects of usability for which validity and/or reliability have been established include the Questionnaire for User Interface Satisfaction (QUIS), the Perceived Usefulness and ease of Use (PUEU), and Nielsen's Attributes of Usability (NAU) among others (Perlman, 2011). The questionnaire used in this research (Appendix 5) incorporated aspects of these questionnaires.

Table 4.17 shows the scores for participants in each category. Participants in the Digital Expertise category consistently scored the usability components higher than all the other categories, with one exception, "ease of use" in which the score was the second highest after the Digital Literacy category. An interesting observation is that participants in the Digital Literacy category consistently scored all the usability elements higher than participants in the Digital Competence category. The participants in the Digital Competence category consistently scored the usability components lower than all the other categories with one exception, the "ease of use" in which they were the second lowest after the Digital Awareness category. Participants in the Digital Awareness category scored all the usability components lower than the Digital Literacy and Digital Expertise categories.

**Table 4.17: Average scores for usability components for participants per digital proficiency level
(Based on five-point Likert scale)**

Participant	Participant's assessment of					Average
	Ease of use (1.1 to 1.6)	Efficiency (2.1 to 2.5)	Effectiveness (3.1 to 3.3)	Easy to remember (4.1 to 4.2)	Satisfaction (5.1)	
DA1	5.00	5.00	5.00	5.00	5.00	5.00
DA2	3.00	3.80	3.33	3.50	3.00	3.51
DA3	4.80	4.60	5.00	5.00	5.00	4.84
DA4	3.80	3.60	3.67	4.00	4.00	3.74
DA5	5.00	5.00	5.00	5.00	5.00	5.00
Average	4.40	4.40	4.40	4.50	4.40	4.44
DL1	4.80	4.20	4.33	4.00	5.00	4.33
DL2	4.40	3.60	4.33	4.00	5.00	4.02
DL3	4.80	4.00	3.67	4.50	5.00	4.13
DL4	5.00	5.00	5.00	5.00	5.00	5.00
DL5	5.00	5.00	5.00	5.00	5.00	5.00
DL6	4.80	5.00	4.33	5.00	5.00	4.82
Average	4.81	4.47	4.44	4.58	5.00	4.63
DC1	4.00	4.20	4.00	4.00	5.00	4.15
DC2	4.40	4.20	4.33	3.50	4.00	4.10
DC3	5.00	4.20	4.67	5.00	4.00	4.55
DC4	5.00	3.60	3.67	4.00	5.00	3.95
DC5	4.60	3.80	3.67	3.00	4.00	3.67
DC6	4.80	4.60	5.00	4.50	5.00	4.74
Average	4.67	4.10	4.22	4.00	4.50	4.35
DE1	5.00	5.00	5.00	5.00	5.00	5.00
DE2	4.60	4.80	4.67	5.00	5.00	4.82
DE3	4.20	4.20	4.67	4.50	5.00	4.44
DE4	5.00	4.60	4.67	5.00	5.00	4.77
Average	4.75	4.65	4.75	4.81	5.00	4.76

Table 4.18 shows the average scores per digital proficiency level of the post-test questionnaire.

**Table 4.18: Average scores for usability components per digital proficiency level
(Based on five-point Likert scale)**

	Participants' assessment of					Average
	Ease of use (1.1 to 1.6)	Efficiency (2.1 to 2.5)	Effectiveness (3.1 to 3.3)	Easy to remember (4.1 to 4.2)	Satisfaction (5.1)	
Digital Awareness	4.40	4.40	4.40	4.50	4.40	4.40
Digital Literacy	4.81	4.47	4.44	4.58	5.00	4.63
Digital Competence	4.67	4.10	4.22	4.00	4.50	4.35
Digital Expertise	4.75	4.65	4.75	4.81	5.00	4.76
Average	4.66	4.40	4.45	4.47	4.73	

The average mean value for “ease of use” was 4.66. For efficiency this was 4.40, and 4.45 for effectiveness. The average means for “easy to remember” was 4.47, and 4.73 for satisfaction. Efficiency had the lowest average at 4.40, and the highest average was 4.73 for “Satisfaction”. The overall mean of the first four elements, “ease of use”, efficiency, effectiveness and “easy to remember is 4.50. This compares fairly well to the mean of 4.73 obtained for the satisfaction with the way the system works. Table 4.19 shows the other descriptive statistics of the mean values of responses of all the participants in the post-test questionnaire. The standard deviation is low ranging between 0.359 and 0.944. This indicates that participants agreed with each other on the level of usability of the LMS.

Table 4.19 – Minimum, maximum and Standard Deviation for User satisfaction - Usability testing post-test questionnaire

		Minimum	Maximum	Std. Deviation
1. Ease of use				
1.1	Language used is easy to understand	4	5	.359
1.2	Words used are similar to words that I am used to	2	5	.717
1.3	It is easy to read words on the screen	3	5	.512
1.4	It is easy to understand pictures on the screen	3	5	.577
1.5	It is easy to follow the way information is arranged	3	5	.730
1.6	It is easy to see options I have selected	2	5	.811
2. Efficiency				
2.1	When I make a mistake I get a clear message	2	5	.944
2.2	The EXITs are clearly marked in case I need to exit the screen	3	5	.590
2.3	The screens look similar and are easy to follow	2	5	.814
2.4	Users with little computer experience can use this system	3	5	.730
2.5	The system is designed for all levels of users	3	5	.740
3. Effectiveness				
3.1	The instructions on what to do are clear	3	5	.644
3.2	I can see the next option to click	3	5	.598
3.3	It is easy to see the HELP documents	3	5	.837
4. Easy to remember				
4.1	The screen layout makes it easy to remember	3	5	.598
4.2	The words used when I make a mistake help me to learn	2	5	.796
5. Satisfaction				
5.1	I am satisfied with the way the system works	3	5	.561

Although participants in all categories agreed that the language used is easy to understand, data collected through visualisation shows that some of the participants in the Digital Awareness and Digital Literacy categories required assistance with the meaning of words such as “folders” and “attach” as discussed in section 4.3.6. The results show the importance of not relying on just one method of data collection such as the questionnaire when testing usability. Through triangulation (section 3.9), checking and rechecking the consistency of the findings, integration of the evidence provides more robust findings. If the questionnaire was the only measure of usability used in the research, the LMS would seem to be usable, while the data collected through eye tracking and interviews demonstrated that some users, particularly in the Digital Awareness and Digital Literacy categories, struggled with some of the tasks.

4.7 Conclusion

The analysis of the questionnaire used in the e-Skills assessment included the Bartlett’s test of Sphericity which yielded a p-value (Sig.) of 0.000, indicating a strong enough correlation between the questions. This meant that factor analysis could be performed. The Kaiser-Meyer-Olkin measure of Sampling Adequacy (KMO) for Dimension 1 (self-assessment of e-Skills) was 0.844. The KMO for Dimension 2 (the accuracy of the simulated competence-based assessment to accurately assess the participant’s e-Skills), was 0.849. Reliability of the questionnaire is adjudged, as shown by the Cronbach Alpha values for Dimension 1 and 2 which were 0.883 and 0.887 respectively.

Based on the performance in the simulated online competence-based assessment, 17% were in the Digital Awareness category. There were 47% participants in the Digital Literacy category, 28% in the Digital Competence and 8% in the Digital Expertise category. The Digital Awareness and Digital Literacy categories, accounted for 64% of the participants. Individuals in the Digital Awareness category are characterised by the lack of basic ICT concepts, and at the Digital Literacy level individuals possess essential ICT skills. Thirty six percent (36%) of the participants were in the Digital Competence and Digital Expertise categories. At the Digital Competence level the individual can operate a range of applications effectively in society and in the workplace. At the Digital expertise level,

individuals possess a high level of ICT skills to be able to exploit the potential of ICT fully within specific advanced roles and applications.

There were more usability problems experienced by participants in the Digital Awareness and Digital Literacy categories. These included incorrect login to myUnisa instead of selecting the myLife option, inability to access the myLife e-mail due to invalid login details, and inability to identify where to click in order to attach the document to the e-mail. Other usability problems experienced by these participants included incorrect selections in order to access the “Official study material” in Task 2. Some of the usability problems that were experienced by participants in the Digital Awareness and Digital Literacy categories were observed to be associated with the participants’ lack of understanding of terminology such as “Attachment” and “Post a comment”. Differences in self-efficacy among participants can be derived from the comments that participants made during interviews. Examples of such comments from participants in the Digital Awareness and Digital Literacy are, “I am not good with computers”, and “I did not expect to do some tasks because I do not have a computer”. Conversely, some of the comments from participants in the Digital Competence and Digital Expertise categories were “the interface is simple and clear”.

The eye tracking data, scan paths, fixations and heat maps, visually represented the differences in the search and usage patterns. The combined heat maps and gaze plots show the shortest scan paths and the fewest fixations on task-relevant areas of the interface by participants in the Digital Expertise category. This indicates an efficient search. In comparison, participants in the Digital Awareness and Digital Literacy categories exhibited the longest scan paths and highest number of fixations, indicating an inefficient search strategy and lack of confidence by these participants. Visualisations of participants in the Digital Competence category showed a more efficient search strategy than the Digital Awareness and Digital Literacy categories, but still less efficient than the digital Expertise category.

The post-test questionnaire completed by participants after each of the usability testing sessions, evaluated the ease of use, efficiency, effectiveness, ease with which the system could be remembered, and satisfaction. Most of the participants agreed with the

statements as shown by the mean values that were all greater than 4 on the five-point Likert scale. This means that the participants, in general, found the LMS highly usable.

Chapter 5: Discussion of Findings and Conclusions

5.1 Introduction

“Interpretation is part of the bedrock of the research process” (Remenyi & Bannister, 2012, p73). This chapter discusses and interprets the findings of the study outlined in Chapter 4, and draws insights based on the results of the analysis. This research set out to answer the main research question as stated in section 1.3.1, which is:

“What is the relationship between the e-Skills competencies of first year university students and the usability problems they experience when using a LMS in an ODL environment?”

In order to answer this question, four sub-questions had to be answered. This chapter shows how each sub-question was answered.

5.2 Students in an ODL environment have diverse e-Skills proficiency levels

The first sub-question was: *What are the e-Skills competencies of first year university students?*

The findings of this study are that the majority of first year students, 64%, in the ODL environment are in the Digital Awareness and Digital Literacy levels of digital proficiency. The rest of the students, 36%, belong to the Digital Competence and Digital Expertise levels of the e-Skills proficiency framework.

Individuals in the Digital Awareness category are characterised by the lack of basic ICT concepts, and although at the Digital Literacy level individuals have basic understanding of ICT concepts, they only possess basic ICT skills but cannot operate most applications effectively. Of the 64% in these two categories, 17% were in the Digital Awareness category and 47% in the Digital Literacy category – the category with the highest number of participants.

There were 28% participants at the Digital Competence level and 8% at the Digital Expertise level, accounting for 36% of the 86 participants who participated in the simulated competence-based e-Skills assessment. At the Digital Competence level individuals can operate a range of applications effectively, and at the Digital Expertise level the individuals possess a high level of ICT skills such that they can be able to exploit the potential of ICT fully within specific advanced roles and applications, as explained in section 2.4.

This research highlighted the diversity of e-Skills proficiency of first year university students in an ODL institution. Evidence gathered in the study showed differences in the performance of the tasks among participants in the different levels of digital proficiency. This confirms the findings made in previous research that students' ICT skills vary greatly, which influences their ability to use the LMS and therefore their learning (Pretorius et al., 2010). These findings suggest that educators and designers of LMSs need to be aware of varying e-Skills of the students and the effect this might have on their ability to use the LMS effectively.

A general guideline that can help all e-Learning designers in an ODL environment is to consider this diversity. Terms such as "Attach" and "Post" were not understood by some participants in the Digital Awareness and Digital Literacy categories. Designers should not assume that users will understand the language and terminology that they themselves are used to, but should find ways to help these users through the use of meaningful icons and by giving more descriptive captions.

5.3 Usability problems experienced

The second sub-question was: *“What are the usability problems experienced by first year university students when using a LMS in an ODL environment?”*

Most of the usability problems experienced by students were interface problems. Other usability problems were related to browsing, feedback and error management. Section 2.2.6 explained the different types of usability problems that have been identified in LMSs (Freire et al., 2012). Usability problems experienced by participants in different levels of digital proficiency in Tasks 1, 2 and 3, were shown in Tables 4.14, 4.15 and 4.16 respectively. Table 5.1 is a summary of the number of usability problems experienced per level of digital proficiency. More usability problems, 32 problems of a total of 42 (76%), were experienced by participants in the Digital Awareness category (18) and Digital Literacy category (14) compared to those experienced by participants in the Digital Competence (5) and Digital Expertise (5) categories (24% of the total problems). Some usability problems were experienced by more than one user within a category. The column “Frequency with which problems encountered” reflects this. There were 50 encounters of problems of the total 63 (79%) made by participants in the Digital Awareness category (31) and Digital Literacy category (19) as compared to only 13 (21%) encounters by participants in the Digital Competence (5) and Digital Expertise (8) categories.

Table 5.1 Summary of usability problems and frequency of encounters per digital proficiency level

Level of digital proficiency	Numbers of usability problems experienced	Frequency with which problems encountered
Digital Awareness	18	31
Digital Literacy	14	19
Digital Competence	5	5
Digital Expertise	5	8

E-skill proficient users in the Digital Expertise and Digital Competence categories consistently performed better than less proficient users in all three tasks. In Task 1 where users needed to identify the myLife e-mail icon at the bottom of the screen, there were users in all the four categories who did not identify this icon but rather logged on to

myUnisa. This usability problem relates to the position and size of the myLife e-mail icon. For these users the correct option was not clearly visible and could not be distinguished on the screen. Some usability problems were unique to participants in the Digital Literacy category, for example, one participant used their National “ID” number to login to the myLife e-mail system for Task 1 instead of the assigned UserID. However, one of the usability problems was that the system required two logon details for the myLife e-mails and myUnisa, resulting in myLife logon details not being remembered by some users although myUnisa logon details were known. Although these participants remembered the myUnisa logon details, they struggled with the logon details for the e-mails. The usability problems encountered by all participants in the different digital proficiency levels for all the tasks have been discussed in detail in Chapter 4. Table 5.2 summarises these problems.

Table 5.2 – Summarized usability problems experienced by participants with different e-Skills proficiency

	Usability problem	Participants who experienced problem				
		DA (5)	DL (6)	DC (6)	DE (4)	Total (/21)
1	<ul style="list-style-type: none"> In Task 1, the myLife icon was not clearly visible 	DA2 DA3 DA4 DA5	DL1 DL2	DC4	DE1 DE3	9
2	<ul style="list-style-type: none"> The correct option was not visible In Task 2 users selected other options instead of Official Study Material 	DA1 DA2 DA3	DL4		DE3 DE4	6
	<ul style="list-style-type: none"> Some users did not see the tutorial letter T101 for the module, which was positioned at the bottom of the list 					
3	<ul style="list-style-type: none"> System required two logon details, resulting in myLife logon details not being remembered although myUnisa logon details known 	DA1 DA2 DA3	DL1 DL2			5
4	<ul style="list-style-type: none"> Relevant options for Task 3 were not visible to the users. 	DA1 DA3		DC2 DC3	DE1	5
	<ul style="list-style-type: none"> Users did not see where to type the comment, and had to be instructed to scroll down 					
	<ul style="list-style-type: none"> Did not identify Submit icon, as a way to post the comment 					
	<ul style="list-style-type: none"> Did not click on Submit in order to post the comment after writing it, and navigated to the next screen without posting the comment. When asked about this, the participant responded, “I forgot” 					

Table 5.2 (cont.) – Summarized usability problems experienced by participants with different e-Skills proficiency

	Usability problem	Participants who experienced problem				
		DA (5)	DL (6)	DC (6)	DE (4)	Total (21)
5	<ul style="list-style-type: none"> Help documentation for participants who did not identify where to click to add an attachment to an e-mail, the online assistance on how to do this was not easy to find 	DA4 DA5	DL1 DL6			4
6	<ul style="list-style-type: none"> Language used did not clearly describe the option for the user: Official study material option not considered as option for accessing the tutorial letter T101, and therefore participants did not recognize correct icon to click to open 	DA2	DL3 DL4	DC3		4
7	<ul style="list-style-type: none"> Discussion Forum option not easily seen or selected in order to post the comment 	DA1	DL2 DL4		DE3	4
8	<ul style="list-style-type: none"> The system does not give adequate support or error messages for participants with less e-Skills proficiency 	DA1 DA3 DA5				3
	<ul style="list-style-type: none"> User did not know how to logon, and did not know the position of “@” on keyboard, and unable to access the LMS without external assistance 					
	<ul style="list-style-type: none"> User who is not aware or is unable on how to set capital letters when typing username, such a user might be unable to logon to the system 					
9	<ul style="list-style-type: none"> Visibility of interactive messages: Users did not see feedback that read “Your reply has been successfully recorded” 		DL1		DE1 DE3	3
10	<ul style="list-style-type: none"> Option to select in order to navigate to an on-going discussion not clear, resulting in user selecting <i>Add new topic</i> 		DL5	DC4		2
11	<ul style="list-style-type: none"> The visible area below the last comment seemed to be the typing area; the correct typing area was not visible resulting in users attempting to type the comment at the wrong place 	DA1 DA3				2

Table 5.2 (cont.) - Summarized usability problems experienced by participants with different e-Skills proficiency

	Usability problem	Participants who experienced problem				
		DA (5)	DL (6)	DC (6)	DE (4)	Total (21)
12	<ul style="list-style-type: none"> The system did not provide clear information about what logon details were required to access myLife. A participant even attempted to use their National "ID" document number instead of the Username. Yahoo login details were also used in an attempt to logon to myLife e-mail 		DL2			1
13	<ul style="list-style-type: none"> The system did not provide an error message to indicate to the user that the document was already attached to the e-mail, even when the user repeatedly attached the same document 4 times, and eventually opened, cut and pasted it to the e-mail 		DL5			1
14	<ul style="list-style-type: none"> The error message that popped-up during login to myUnisa was not visible to the user. The message was not visible to the user 	DA1				1
15	<ul style="list-style-type: none"> Language or terminology used not easy to understand - Did not understand the instruction "Post a comment", but understood when it was explained as "write" a comment 	DA1				1
	<ul style="list-style-type: none"> After typing comment asked where comment should be "attached". Concept "Post" and "Attach" confused 					
16	<ul style="list-style-type: none"> Inadequate feedback for a repeated error where a user keeps repeating the same error. For example, in Task 3 user kept clicking on the first comment posted on the discussion forum (10 times) trying to "open" it, until instructed to scroll down 	DA3				1

Some usability problems, such as transpired in Task 3 where the Submit button and the writing area were not visible unless participants scrolled down, were also experienced by

participants across the four categories. It can be noted however that participants in the Digital Competence and Digital Expertise categories not only encountered fewer usability problems but also reacted to them differently, requiring less assistance and focussing on quickly completing the tasks. The usability results as presented in section 4.4 show a distinction between the usability problems experienced by users in the Digital Awareness and Digital Literacy categories in comparison to those experienced by participants in the Digital Competence and Digital Expertise categories.

This is supported by the eye tracking visualisations in the form of combined heat maps and gaze plots. In a comparative analysis of users of technologically interactive surfaces, Popovic (2007) noted that users with lower levels of e-Skills show more uncertainty and trial and error, while expert users exhibited characteristics of problem awareness and performed better in the tasks.

As LMSs are fast becoming indispensable tools for students it is necessary to identify the usability problems that students experience when using the LMS. The introduction of compulsory online signature modules for undergraduate students from 2013 at the ODL institution, Unisa, where this study took place makes identifying usability problems even more critical. This closely relates to the need to identify the students that experience these problems, and determining what form of assistance they require.

5.4 How the usability problems relate to e-Skills levels

The third sub-question was: *“How are the usability problems identified related to the e-Skills levels of the users?”*

E-Skill proficient users in the Digital Expertise category performed better than less proficient users in all three tasks. It was, however found that although the relationship between the usability problems experienced and e-Skills proficiency exists, participants who used the LMS more often performed better. This is shown by the completion times, supported by the gaze plots and heat maps of two participants in the Digital Awareness

and Digital Literacy categories. These participants use my Unisa regularly, at least three times per week, as established during the interviews. Even though they were in the Digital Awareness and Digital Competence categories the completion times for participants DA4 and DL3 were very close to those of participants in the Digital Expertise category. The total completion time for participants DA4 and DL3 for all three tasks was 8 minutes, compared to the average of 6 minutes for participants in the Digital Expertise category. The average total completion time for the participants in the Digital Awareness group was 15 minutes.

The differences in the amount of time taken to perform tasks, the usability problems encountered and the gaze patterns shown by users in different levels of e-Skills proficiency highlighted the diversity of e-Skills proficiency among the participating first year students in the ODL environment who participated in the research. The types of usability problems experienced by users, and the percentage (%) composition of users who experienced the problem are shown in Table 5.3.

Table 5.3 – Percentage (%) of students who experienced the usability problems per category

	Usability problem	% composition of participants who experienced problem				
		DA (5)	DL (6)	DC (6)	DE (4)	Total (21)
1	<ul style="list-style-type: none"> The correct option in Task 1, the myLife icon was not clearly visible and users could not distinguish it on the interface 	80	33	17	50	43
2	<ul style="list-style-type: none"> The correct option was not visible In Task 2 users selected other options instead of Official Study Material. 	60	17		50	29
	<ul style="list-style-type: none"> Some users did not see the tutorial letter T101 for the module, which was positioned at the bottom of the list 					
3	<ul style="list-style-type: none"> System required two logon details, resulting in myLife logon details not being remembered although myUnisa logon details known 	60	33			24

Table 5.3 (cont.) – Percentage (%) of students per category who experienced the usability problems

	Usability problem	% composition of participants who experienced problem				
		DA (/5)	DL (/6)	DC (/6)	DE (/4)	Total (/21)
4	<ul style="list-style-type: none"> Relevant options for Task 3 were not visible to the users resulting in: 	40		33	25	24
5	<ul style="list-style-type: none"> Help documentation 	40	33			19
	<ul style="list-style-type: none"> For participants who did not identify where to click to add an attachment to an e-mail, the online assistance on how to do this was not easy to see 					
6	<ul style="list-style-type: none"> Language used does not clearly describe the option for the user: Official study material option not considered as option for accessing the tutorial letter T101, and therefore participants did not recognize correct icon to click to open 	20	33	17		19
7	<ul style="list-style-type: none"> Discussion Forum option not easily seen or selected in order to post the comment 	20	33		25	19
8	<ul style="list-style-type: none"> Visibility of interactive messages: Users did not see feedback that read “Your reply has been successfully recorded” 		17		50	14
9	<ul style="list-style-type: none"> The system does not give adequate support or error messages for participants with less e-Skills proficiency - User did not know how to logon, and did not know the position of “@” on keyboard, and unable to access the LMS without external assistance - User who is not aware or is unable on how to set capital letters when typing username, such a user might be unable to logon to the system 	40				12
10	<ul style="list-style-type: none"> Selected incorrect option, Add new topic, instead of selecting an on-going discussion as instructed. 		17	17		10
11	<ul style="list-style-type: none"> Attempted typing the comment in incorrect area, in the line following the last comment made in the discussion 	40				10

Table 5.3 (cont.) – Percentage (%) of students per category who experienced the usability problems

	Usability problem	% composition of participants who experienced problem				
		DA (5)	DL (6)	DC (6)	DE (4)	Total
12	<ul style="list-style-type: none"> The system did not provide clear information about what logon details were required to access myLife. A participant even attempted to use their National "ID" document number instead of the Username. Yahoo login details were also used in an attempt to logon to myLife e-mail 		17			5
13	<ul style="list-style-type: none"> The system did not provide an error message to indicate to the user that the document was already attached to the e-mail, even when the user repeatedly attached the same document 4 times, and eventually opened, cut and pasted it to the e-mail. 		17			5
14	<ul style="list-style-type: none"> The error message that popped-up during login to myUnisa was not visible to the user. The message was not visible to the user. 	20				5
15	<ul style="list-style-type: none"> Language or terminology used not easy to understand - Did not understand the instruction "Post a comment", but understood when it was explained as "write" a comment. 	20				5
	<ul style="list-style-type: none"> After typing comment asked where comment should be "attached". Concept "Post" and "Attach" confused 					
16	<ul style="list-style-type: none"> Inadequate feedback for a repeated error where a user keeps repeating the same error. For example, in Task 3 user kept clicking on the first comment posted on the discussion forum (10 times) trying to "open" it, until instructed to scroll down. 	20				5

The figures show the percentage of students who experienced the problem within each category. The last column shows the percentage of students, out of the total of 21 participants, who experienced the problem. For example visibility of the myLife icon was one of the major usability problems that users encountered. This problem was encountered by 43% of the participants. The usability problems have been listed in order, from the highest to the lowest.

Constructivists view learning as a personal, subjective interpretation of the world which occurs as the individual interacts with the environment, a process during which knowledge

is constructed (Carlie et al., 2004). While some usability problems were experienced at all levels of e-Skills proficiency, more usability problems were experienced by students at the lower levels. From a constructivist perspective more opportunity should be afforded students at the lower e-Skills levels for them to become familiar with the LMS. The concept of familiarity defined by Dix, Finlay, Abowd and Beale (2004) as the ability of an interactive system to allow a user to map prior experiences, either real-world or gained from interaction with other systems, onto the features of a new system, play an important part in enhancing usability. This closely relates to the learnability of the system. The frequency of use of the LMS by students is therefore an important factor that influences the efficiency with which they can use the LMS.

Self-efficacy seems to have an effect on the performance on the tasks. Participants in the Digital Expertise category, who had not used the online discussion forum, still performed as well as the others in the same category who had used it before. They pointed out that the system was simple, clear and the tasks were easy to perform. These participants showed a higher level of confidence in their ability to perform the tasks even though they had not used the system before. This observation is relevant in that it can encourage students such as participant DL2 who may think that “they are not good with computers”, to realize that although digital proficiency is important, the frequent use of the system is equally important.

The findings in this research have shown that there is a relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students’ e-Skills competencies. Students with more e-Skills found less usability problems than those with less e-Skills. This answers the third sub-question “how are the usability problems identified related to the e-Skill levels of the users?”

5.5 What eye tracking reveals

The fourth sub-question was: *“What does eye tracking reveal about the relationship between the usability problems and the e-Skills competencies of the students?”*

There were more usability problems experienced by students at lower levels of e-Skills proficiency. The results shown by the heat maps and gaze plots of these students in section 4.5 provide evidence of less efficiency in searching for information in the LMS by participants at these lower levels. Students at higher levels of e-Skills proficiency, however, performed tasks faster and more accurately as shown by their gaze patterns. Gaze plots of students at the higher e-Skills proficiency showed fewer fixations on task-relevant areas of the interfaces, depicting greater efficiency in the use of the LMS. Eye tracking data provided visual evidence for usability problems experienced by participants in addition to the information obtained through interviews and observations. This is important because users often find it difficult to explain exactly what their problem is. This may be more pronounced in situations where the individuals do not know what to measure themselves. Eye tracking in this study was particularly important in visually showing the differences in the gaze patterns of students at different levels of e-Skills proficiency that explained the observed differences in task completion times.

As a caution, interpretation of eye tracking data should be judiciously applied, hence the value of triangulation in this research. The heat map of one participant if considered on its own could distort the group heat map if not interpreted correctly, for example if the participant performed the task in a very different way.

5.6 Implications for design

The fifth sub-question was: *“What are the implications of this information for e-Learning designers involved in the design of the user interface of a LMS in the ODL environment?”*

As noted in the literature review in section 2.2, usability is 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 (ISO, 1998). Within the context of this definition of usability, the following points can be noted regarding implications for design:

1. Sixty (60%) of the students in the Digital Awareness and 33% in the Digital Literacy categories were unable to complete Task 1 in which they had to logon to the e-mail system and send a document. The main reason was because they were unable to

access the system. Two separate login processes for the myLife e-mail and myUnisa confused users. These participants, mostly in the Digital Awareness and Digital Literacy categories remembered their myUnisa passwords but could not remember their myLife e-mail system login details. This could be due to infrequent use. However a single login system can contribute to ease-of-use.

Recommendation: A single set of logon details should be used to access all the facilities of a LMS.

(It can be noted that this point has since been addressed because during the writing of this report a single login process was introduced, as discussed in the “New simplified login to the LMS” in section 4.4.2.1).

2. It is not easy to see the myLife icon in its current location. In Task 1, in which participants had to select the myLife e-mail icon in order to send an e-mail, some participants did not see it. Although there were relatively more participants in the Digital Awareness category who made this error, the error was committed by participants in all four categories. The latest version of the LMS, myUnisa, addresses this point.

Recommendation: Large and conspicuous icons should be used as far as possible.

3. Participants need to scroll down in the Online Discussion Forum page in order to view the typing area or the Submit option. This should be avoided. This is because it may cause some users not to immediately identify the area where they should type the comment. The Submit button needs to be visible.

Recommendation: Minimize scrolling and rather position the Submit button and the typing area where they are clearly visible.

4. When participant DC2 “forgot” to click on the Submit button to post the comment on the Online Discussion Forum in Task 3, no error message notified her of the mistake.

Recommendation: Provide error messages where necessary.

5. The interactive message “Your reply has been successfully recorded”, which appears once the comment has been posted in Task 3, was not easy to see. Several participants including participants DL1, DE1 and DE3 asked whether the comment had been posted or not.

Recommendation: Interactive messages should be positioned where they are easy to see. A conscious effort should be made to ensure that they are visible.

As a general guideline, in applying user-centred design principles discussed in section 2.2.10, e-Learning designers in an ODL environment should be cognisant of the following issues presented in Figure 5.1:

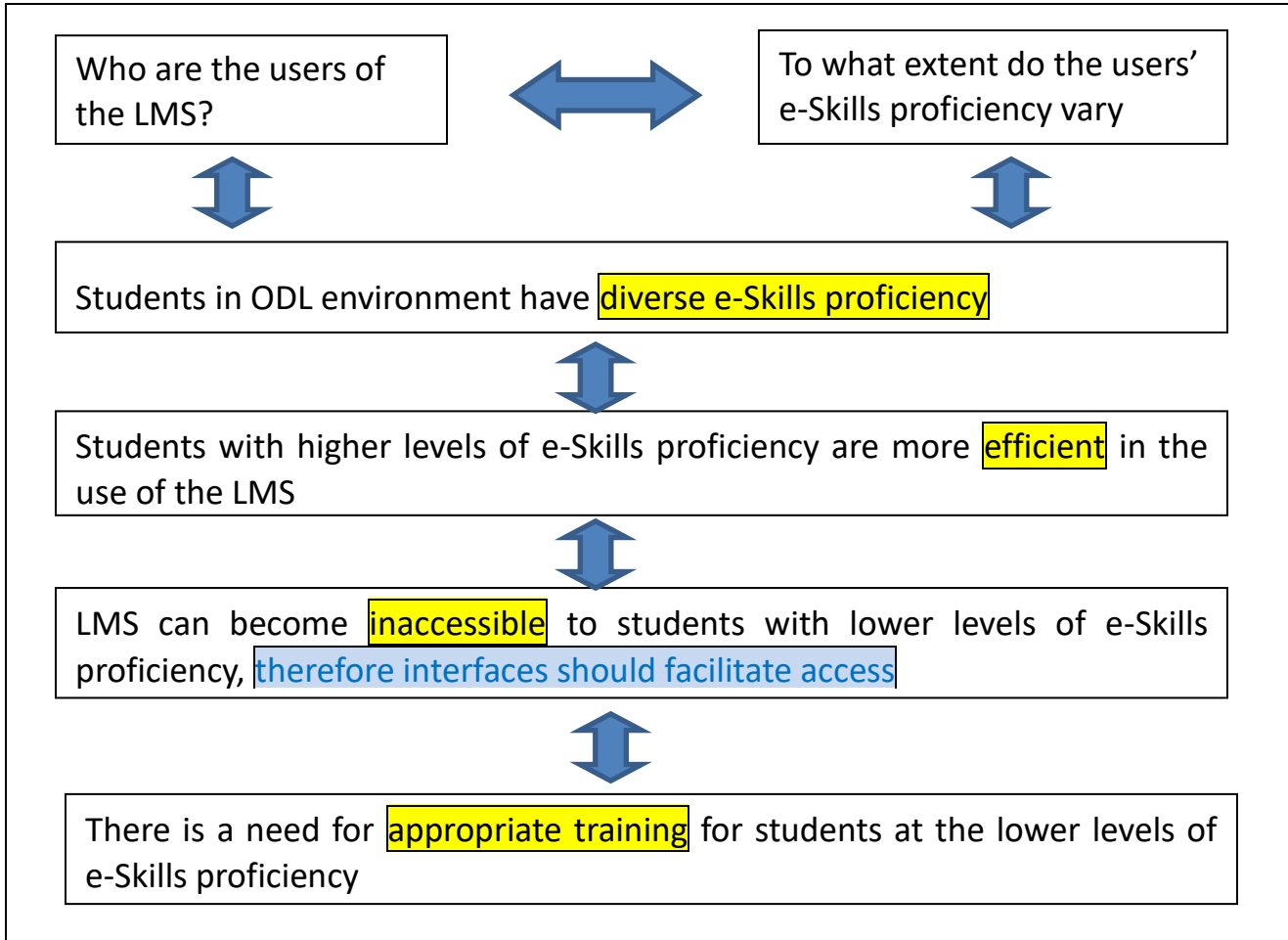


Figure 5.1: Implications for design and considerations from the research

Usability of an LMS is important and designers need to strive for ease of use. However, students also have a responsibility. They need to take the necessary action to register to use the LMS, learn to use it, and use it as often as possible. Components of usability such as the number of errors, and measures such as efficiency and effectiveness of the system (section 2.2.2) are useful. Nonetheless, this information needs to be used together with information such as characteristics and circumstances of the target audience in order to

achieve a holistic assessment of usability. Some errors can be associated with the reading and comprehension abilities of the participants.

The implementation of systems involves training of users (Figure 2.4 and section 2.2.8.2). System designers should design user interfaces that enable users to perform tasks easily. However, in a tertiary ODL institution with student numbers exceeding 300 000 (section 1.5), training of users of the LMS involves different aspects for different departments. Training can enhance the computer literacy of students. Focus should be given to students and instructors' knowledge of learner support already available to students to learn ICT skills at their own pace and in a safe environment where they will not feel intimidated. For example there are resources online provided for students to learn how to use the LMS, as well as applications such as MS Word, PowerPoint and Presentations. Training videos can also be utilized. Information regarding the availability of these resources should be well disseminated, and its usage and impact ascertained.

Eye tracking gives some indication of the differences in levels of cognitive activity between experts and non-experts (Dix et al., 2004). There are significant differences between the cognitive activity levels of experts and non-experts (Law, Atkins, Kirkpatrick & Lomax, 2004). While novice users rely more on declarative knowledge, experts rely more on judgment knowledge and operate at higher cognitive levels by using knowledge from the judgment and wisdom categories (Kotze et al., 2006; Prumper et al., 1991). Interactive interface design should facilitate transition from novice to expert user (Popovic, 2007).

5.7 Limitations of the study

A limitation in this study is that although the simulated competence-based assessment assisted in grouping the participants, some subjectivity persists in that the researcher had to determine the percentage performance levels for each of the digital proficiency categories (Table 4.1). This similarly relates to the application of the set of criteria that the researcher had to apply when determining the usability problems. As Hertzum and Jacobsen (2001) observed, no matter how unambiguously criteria can be defined, when applied, some subjective judgment still has to be made (Hertzum & Jacobsen, 2010).

5.8 Are these usability problems or simply problems in using the LMS?

During usability testing in Task 1, the performance of participants in the Digital Awareness and Digital Literacy categories showed that some of the students did not make use of their e-mails, though freely availed to them by the university. The majority of these students when interviewed responded that they either thought it was difficult or they did not have time to use the LMS as often as they should. Usability evaluation presupposes that difficulties may arise as a result of problems with the interface. There is however a need to consider student action, or lack thereof, such as students who make infrequent use of the LMS. Some students in the interviews indicated that they use the system once a month due to lack of time. Such students can easily forget their password and may not know how to use the system because they have not made enough attempts at using the LMS. Students should be encouraged to make frequent use of the LMS from the onset.

5.9 Conclusion

The study has shown that the usability problems experienced by the participants in different levels of digital proficiency are distinctly different, and that:

The alternative hypothesis (H_1) that there is a relationship between usability problems experienced by the students when using an LMS in an ODL environment and the students' e-Skills competencies is therefore accepted.

Participants in the Digital Expertise category consistently performed better in all three tasks followed by participants in the Digital Competence category. They were more efficient in the amount of time they took completing the tasks and in the search patterns as depicted by the eye tracking visualisations. There were more usability problems encountered by participants in the Digital Awareness and Digital Literacy categories.

The gaze plots showing the number of fixations and the scan paths of the participants also show differences in the digital proficiency categories. Some variation was also observed

within the categories. The scan paths for participants in the Digital Awareness and Digital Literacy categories were longer and had more fixations that were dispersed across the Webpage. This indicated a less efficient search strategy. In comparison, the scan paths of participants in the Digital competence and Digital expertise categories were fewer fixations and more focused on task-relevant areas on the system, showing more efficiency in the search strategy employed by participants in these categories. In general, the more e-Skills competencies the students had, the faster and more accurate they completed the tasks, and the less usability problems they encountered in the LMS.

Chapter 6: Conclusion and Future Research

6.1 Introduction

Usability testing and eye tracking were used in this research to provide visual evidence of usability problems experienced by users with varying e-Skills competence levels. Eye tracking was particularly important in providing visualisations that could be analysed for instances that users might not have been able to describe their problem, or be aware of them.

6.2 Summary of research findings

The mixed method approach, using both qualitative and quantitative data collection and analysis methods provided a comprehensive look at the usability problems experienced by the students. Visual evidence obtained through usability testing and eye tracking (heat maps and gaze plots), triangulated with observation and video recorded interviews were used for data collection. As a result of the pragmatic approach adopted in the research, hypotheses were defined and tested (an element of positivism), and narrative data and analysis utilized (constructivist approach) to define and analyse the usability problems experienced by students with varying e-Skills.

The Digital Proficiency framework with four categories, Digital Awareness, Digital Literacy, Digital Competence and Digital Expertise was used to categorise participants based on their performance in the online simulated competence-based assessment. The e-Skills competence of users of the LMS, myUnisa were related to the usability problems that the participants experienced when using the LMS during usability testing and eye tracking conducted at the Human-Computer Interaction (HCI) laboratory. The measures of usability

of the LMS, efficiency, effectiveness, and user satisfaction, were used to investigate usability problems experienced by participants. Efficiency was based on the amount of time that users in different e-Skills levels took to complete each of the three tasks on the LMS. The number of errors that were made while the tasks were performed gave an indication of the effectiveness of the system. User-satisfaction questionnaires and responses to interview questions were used to ascertain user satisfaction.

The diversity of users should be an important consideration during the design of interactive interfaces. The study showed the diversity of the e-Skills proficiency levels of the first year university students who participated in the research. A smaller proportion of students were in the Digital Expertise (8%) and Digital Competence (28%) levels. The results of the e-Skills assessment showed that a large proportion of the participants were in the Digital Literacy (47%) and Digital Awareness (17%) categories, making up 64% of the participants. The highest proportion of usability problems were exhibited by participants in the Digital Awareness and Digital Literacy categories.

The design of user-interfaces should of necessity be user-centred. The iterative development of user interfaces as described in section 2.2.8, requires that the design be tested by the users and refined based on the evaluation. Usability problems revealed in the research included icons not being distinguishable on the user interface or positioned in areas of the webpage not immediately visible to the user and requiring scrolling. The design of user-interfaces of the LMS in the ODL environment where users are diverse requires that the differences between less e-Skill proficient users in the Digital Awareness and Digital Literacy categories and more proficient users such as the Expertise category be taken into consideration.

6.3 Contributions of the study

This research contributed to identification of usability problems experienced by users with varying e-Skills when using the LMS. The use of three different tasks to evaluate the usability of the user interface of the LMS and triangulation of the user interface of the LMS and triangulating with eye tracking visualisations, video records and interviews provided

relevant information that gave understanding to actions that were observed during usability evaluation. This can assist designers when applying user-centred design principles in the design of user interfaces. The implications for design presented in Chapter 5, which include providing a single login process, using icons that can be easily seen, positioning of the Submit button appropriately can be used for improving the user interface.

The research contributed to e-Skills research and facilitated more research relating to learner support. Departments engaged in learner support, including Unisa's Tuition and Facilitation of Learning department that supported the study and availed the regional learner support centre where the e-Skills assessment took place, can use aspects of the research. As a result of this research, more resources for a study that will assess a larger number of students, four times the number used in this study, have been availed. The planned study will use the same e-Skills assessment developed for this research. After the e-Skills assessment the students will be provided with training for a specific period of time, after which they will again be assessed to ascertain the effect of the training and interventions that will be provided.

6.4 Recommendations and future research

6.4.1 E-Skills assessment for learner support purposes

Based on this information, a recommendation can be made that further investigation be conducted on the provision of e-Skills assessment of more first year students early, soon after first registration. This is in line with responsible "open admission" at Unisa, where admission requirements allow for the removal of barriers to learning, and provides for the assessment of students' level of academic preparedness so that appropriate support systems can be designed for students who need help in addressing academic skills gaps.

Although the research does not directly address the complex reasons of why many students in distance education take a long time to complete and why many of them drop out or fail and do not re-register, based on the types of usability and other related problems shown in this study further investigation is required to ascertain the effect of students' e-

Skills on dropout rates. The necessity for e-Skills assessment of first year students as soon as they are registered, with the view of providing relevant support, should be investigated.

6.4.2 Related future studies

6.4.2.1 Use of computer laboratories at Unisa's regional learner centres

The Tuition & Facilitation of Learning department at Unisa which provides learner support has facilities to assist students to become computer literate. Computers and Internet access is provided free of charge to registered students at the regional learner centres. It is necessary to identify use of these facilities, for example:

- (i) Who are the students that make the most use of these facilities?
- (ii) How can students with low e-Skills be encouraged to use these facilities to develop their e-Skills?
- (iii) What training is provided to students at the regional centres?
- (iv) How relevant is the current training given to students at the learner centres, to their e-Skills development?

6.4.2.2 Use of online computer literacy applications freely available on the LMS

Applications such as MS Word, Excel, PowerPoint, Basic computing, Internet and e-mail use, which students can use at their own pace, to enhance their computer literacy are freely available to registered Unisa students. These are available on the learner support site of the LMS. Research to ascertain the extent to which students are aware of this information, and who uses the facilities can provide valuable information regarding learner support for computer literacy.

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APPENDICES

Appendix 1 – Text copy of the simulated, competence-based e-Skills assessment

Area	Proofing a Document
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {147} Use the Ribbon to Spell check the document. The word imposible is spelled incorrectly and should be corrected to impossible.</p> <p>Answer: 1. Click the Review tab and then Click Spelling and Grammar.2. Click on impossible in the Suggestions box and then Click the Chang button.</p>
Area	Composing Messages
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1463} Use the Home tab to attach the external graphic file named Sunflower.jpg to this message. This file is stored in the default directory.</p> <p>Answer: 1. Click the Attach File button on the Home tab.2. Click the file named Sunflower.jpg and then click the Insert button or press the ENTER key.</p>
Area	Customise a Slide Show Presentation
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {704} Use the Ribbon to set up the presentation to run as an automatically repeating information kiosk.</p> <p>Answer: 1. Click Set Up Slide Show button on the Slide Show tab.2. Select Browsed At A Kiosk (Full Screen).3. Click OK Button, OR Press Enter.</p>
Area	Using Electronic Mail
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1523} Where would you click on the Ribbon to create a new mail message?</p> <p>Answer: 1. Click on the Compose mail button.</p>
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {677} Open the mail message received from lynda.com. Do not use the right-click option. Answer : 1. Click on lynda.com.</p>
Area	Format Text on Slides
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {581} Use a button on the Home tab to change the selected bulleted text to the following numbering style. 1) 2) 3)</p> <p>Answer : Select the 1) 2) 3) numbering option from the Numbering drop-down on the Home tab.</p>
Area	Customising & Enhancing Workbooks & the Excel Environment

	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {1320} Use the Ribbon to insert a comment in the current cell. The comment should read: INCOME FROM RENTAL. Click the Save button when done.</p> <p>Answer: 1. Press the SHIFT+F2 keys OR Review tab / Insert New Comment2. Type INCOME FROM RENTAL and then click the Save button.</p>
Area	Securing & Distributing a Presentation
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {770} Use the Ribbon to set a password (MYPASSWORD) for this presentation.</p> <p>Answer: Office Button / Save As / PowerPoint Presentation / Tools button / General Options / Type MYPASSWORD in the Password to open box / OK.</p>
Area	Customising Message Options
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {3734} Use the Ribbon to create a new distribution list called Applicants and add Joe Black and Mary Poppins to the list.</p> <p>Answer: 1. Click File - New - Distribution List OR CTRL+SHIFT+L.2. Type Applicants.3. Click the Select Members button.4. Click Joe Black and then click member button.5. Click Mary Poppins and then click member button.6. Click Ok button or Press Enter key.</p>
	<p>Test Type: Simulated</p> <p>Weight: Level 3</p> <p>Question: {3731} Have this message delivered at 8:30 AM.</p> <p>Answer: 1. Click the Options Dialog Box Launcher.2. Check Do Not Deliver Before check box.3. Select 8:30 AM from the second Do Not Deliver Before drop-down.4. Click the Close button.</p>
Area	Editing & Formatting Techniques
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question : {1277} Use the shortcut menu to change the spacing between the characters of the selected text to 1.5 pt.</p> <p>Answer : 1. a) Click the Font button, or b) Press the CTRL+D keys, or c) Select Font from the right mouse menu.2. Click the Character Spacing tab. 3. Select Expanded from the Spacing drop-down box. 4. Reset the By option to the right</p>
Area	Locate Outlook Items
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {3766} You have been receiving junk email from the email address bethleheminfo.com. Use the junk email filter to automatically send mail from this address to your Junk E-mail folder.</p> <p>Answer: 1. Click Actions - Junk E-Mail - Junk E-mail Options.2. Click Blocked Senders tab.3. Click Add button.4. Type bethleheminfo.com and then Press OK button.</p>
Area	Getting Started with Outlook
	<p>Test Type: Simulated</p> <p>Weight: Level 3</p> <p>Question: {1472} Create a signature named Closing 1 that includes the following text: If you have any questions, give me a call. John Smith.</p> <p>Answer: 1. Select Signatures from the Signature drop-down on the Insert tab. 2. Click the New button. 3. Type Closing 1 in the Enter a name for your new signature text box.4. Click the OK button. 5. Type If you have any questions, give me a call. John Smith.</p>

	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {777} Select the option that would send a response to the sender and would also send copies of the response to anyone who received the original message.</p> <p>Answer: 1.a) Click the Reply to All button, or b) Press the CTRL+Shift+R keys.</p>
Area	Streaming Workflow
	<p>Test Type: Simulated</p> <p>Weight: Level 3</p> <p>Question: {320} You created a macro named NewFormat that will Italicize column Headings and format numerical data to currency. Show the steps to run the macro. You cannot remember the shortcut key to run the macro.</p> <p>Answer: 1. View tab/ Macros / View Macros2. Select NewFormat then click the Run key</p>
Area	Creating a Document
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {963} Use the Office button to save this document a new folder on the local disk (C:). Name the new folder Testing and open the folder. (Click to type folder name, do not use Enter)</p> <p>Answer: 1. Click the Office Button and then select Save As Word Document.2. Click Local Disk (C:) on the drop down box.3. Click on the Create New Folder button on the toolbar.4. Type Testing in the dialog box.5. Click Open.6. Type #1Testing in the File name:</p>
Area	Importing & Exporting Data
	<p>Test Type: Simulated</p> <p>Weight: Level 3</p> <p>Question: {1260} Import a text file named Test copy1.txt into this document. The file contains entries separated by tabs. Numeric values must be converted to numbers.</p> <p>Answer: 1. On the Data menu, Get External Data from.2. a) Select Test Scores.txt and then click on the Import button or press the ENTER key, or b) Double-click Test Scores.txt.3. Click the Next button. 4. Click the Next button. 5. Click the Finish button.</p>
Area	Exploring Your Computer
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question : {3263} Use a menu to change the appearance of the files to that of Details.</p> <p>Answer : 1. Click the View Menu2. Select Details</p>
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question : {3262} Using the appropriate icon, view the folder names one level before the currently selected folder.</p> <p>Answer : 1. Click the back Icon</p>
Area	Organizing Messages
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1318} Use the shortcut menu to sort the contents of the Inbox folder by subject.</p> <p>Answer : Right click Arrange By: and then select Subject.</p>
Area	Inserting Graphic Objects

	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1390} Use the Ribbon to insert the picture named tulips.jpg (in the default folder) in the current document.</p> <p>Answer: 1. Click the Insert Picture from button on the Insert tab.2. Double-click on tulips.jpg, alternatively click sunflower.jpg and then click the Insert button.</p>
Area	Organizing Worksheet & Table Data
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {1359} Use the Ribbon to filter the records in the current database to display only the records where the SALARY is between 2000 and 5000 (hint: after typing in the numbers click into the next text box to confirm the input. then click OK.)</p> <p>Answer: 1. Select Filter from the Sort & Filter drop-down on the Home tab. 2. Click the Total Pay drop down box.3. Click Number Filters and Select Greater than or Equal to4. Type 2000 in the Greater than or equal to box. 5. Type 5000 in the Less than or equal</p>
Area	Additional PowerPoint Questions
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {502} There are currently two presentations open. Use the Ribbon to display the two open presentation windows side-by-side.</p> <p>Answer: 1. Select Arrange All on the View tab.</p>
Area	Managing Lists
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {318} Use a button on the Home tab to change the numbered list to include a hierarchical structure. Make the selected items a lower level of the list.</p> <p>Answer : 1. Click Increase Indent on the Home tab.</p>
Area	Getting Started with PowerPoint
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1407} Use the Home tab to add a new title and content slide to this presentation. Add a title named New Courses and the following bullet Microsoft Office PowerPoint. Click the Save button when done.</p> <p>Answer: 1. Select Title and Content from the New Slide drop-down. 2. Click on the title area and type New Courses. 3. Click on the bullet area and type Microsoft Office PowerPoint. 4. Click the Save button.</p>
Area	Using Design Templates
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {932} Use the Ribbon to add a date on the footer of all the slides. The date must update automatically from day to day. Save the presentation as a template after adding the footer.</p> <p>Answer 1. Select Header & Footer on the Insert tab.2. Click the Date and time check box.3. Click the Update automatically radio button. 4. Click on the Apply to All button. 5. Select Save As - Other Format from the Office Button drop-down.6.</p>
Area	Performing Calculations

	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {268} Use AutoSum button to create a formula that totals column B. The formula will be automatically place in the correct cell.</p> <p>Answer: 1. In the Formula Tab Click AutoSum Button and select Sum.</p>
Area	Inserting Charts in a Presentation
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {3379} Use the Ribbon to insert a Microsoft PowerPoint Pie chart (select the second Pie Style from the gallery).</p> <p>Answer: 1. Select Chart from the Insert tab.2. Click on the Pie option.3. Select the second Pie chart.</p>
Area	Searching the World Wide Web
	<p>Test Type: Simulated</p> <p>Weight: Level 1</p> <p>Question: {1511} Use the Search engine to find Webpages with information about gardening. Click on the Go button when you have finished typing, DO NOT press Enter.</p> <p>Answer: 1. Type gardening.3. Click the Go button.</p>
Area	Modifying Pictures
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {166} You want to reduce the size of the selected picture to 96 ppi so that you can send it via E-mail. Show the steps to do this.</p> <p>Answer: 1. Format tab / Compress Pictures.2. Click Apply to selected pictures only Text box.3. Click Options button.4. Click E-mail (96 ppi): minimize document for sharing Radio button.5. Click OK button.</p>
	<p>Test Type: Simulated</p> <p>Weight: Level 2</p> <p>Question: {333} Use the Ribbon to compress the following image and e-mail it as a PDF Attachment.</p> <p>Answer: 1. Click Compress Pictures button on the Format tab.2. Click OK button.3. Click Office button, click Send and select E-mail as a PDF attachment.</p>

Appendix 2: Consent Form – E-Skills assessment

CONSENT FORM (e-Skills competency)

Please read the statements below. If you would like to take part in the research complete the requested information and sign as indicated.

I am studying towards a MSc (Information Systems) at the University of South Africa (Unisa) where I currently lecture in the School of Computing. The title of the research is: **The relationship between students' e-Skills competencies and the usability problems they experience when using a learning management system (myUnisa) in an open distance learning environment.**

I would like to invite you to take part in this study which is about the online assessment of e-Skills competencies of first year Unisa students. Participation in this research is voluntary. The online e-Skills exercise will take a maximum of 45 minutes to complete. Data will be used for academic research purpose only and will be securely kept for the stipulated timeframe, currently five years, after which it will be destroyed. Note that you have the right to withdraw from this study anytime without any negative and undesirable consequences to yourself.

(Should you agree to participate in this study, please fill in and sign the section below:)

I _____ (Full names - *Optional*), hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Signature _____ Date: _____

(Optional:) Surname: _____

Name: _____ Student number: _____

Thank you for taking part in this research.

Appendix 3: Post-test questionnaire – E-Skills assessment

E-Skills Questionnaire

Background information

1. Student number

--	--	--	--	--	--	--	--	--

2. Year of Study

Year 1		Year 2		Year 3		Year 4	
--------	--	--------	--	--------	--	--------	--

3. Qualification for which currently registered: _____

4. Gender (tick)

Male		Female	
------	--	--------	--

4. Age (years)

<20		21 - 30		31 - 40		41 - 50		>50	
-----	--	---------	--	---------	--	---------	--	-----	--

5. Highest education level

Matric		Diploma		Bachelor degree	
--------	--	---------	--	-----------------	--

Computer use Experience

6. Did you use computers at school?

Y		N	
---	--	---	--

7. Did you study a formal subject such as Computer studies at school

Y		N	
---	--	---	--

8. Do you have access to a computer at home

Y		N	
---	--	---	--

9. How do you consider your knowledge and use of computers to be?

Very little		Average		Good		Excellent	
-------------	--	---------	--	------	--	-----------	--

Work Experience

10. Are you currently employed?

Y		N	
---	--	---	--

11. Do you use computers at work?

Y		N	
---	--	---	--

12. In which area/field do you work?

Information technology		Finance		Education		Engineering		Sales and Marketing		Other (state)	
------------------------	--	---------	--	-----------	--	-------------	--	---------------------	--	---------------	--

On a scale of 1 to 5, where 5 is 'Very good' and 1 is 'not good at all', please rate the extent of your skills in the use of:

	Very good	Above average	Average	Satisfactory	Not good at all
1. myUnisa	5	4	3	2	1
2. Basic computer skills	5	4	3	2	1
3. Internet search engine	5	4	3	2	1
4. E-mail	5	4	3	2	1
5. Microsoft Office Word	5	4	3	2	1
6. Microsoft Office Powerpoint	5	4	3	2	1
7. Microsoft Office Excel	5	4	3	2	1

How well do you think this system actually tested the extent of your skills with respect to

1. Basic computer skills	5	4	3	2	1
2. Internet search engine	5	4	3	2	1
3. E-mail	5	4	3	2	1
4. Microsoft Office Word	5	4	3	2	1
5. Microsoft Office Powerpoint	5	4	3	2	1
6. Microsoft Office Excel	5	4	3	2	1

Would you recommend this type of assessment to determine e-Skills competence?

Yes	No
-----	----

Appendix 4: Usability evaluation – Consent form

CONSENT FORM

(Usability testing and eye tracking)

Please read the statements below. If you would like to take part in the research complete the requested information and sign as indicated.

I am studying towards a MSc (Information Systems) at the University of South Africa (Unisa) where I currently lecture in the School of Computing. The title of the research is:

The relationship between students' e-skills competencies and the usability problems they experience when using a learning management system (myUnisa) in an open distance learning environment.

I would like to invite you to take part in this study which is the usability evaluation of the learning management system (myUnisa) by first year Unisa students. Participation in this research is voluntary. You will take 20-25 minutes to perform three simple tasks for the usability evaluation exercise. However, if you require more time you are free to take longer, up to 40 minutes. Eye tracking data and video records will be collected during performance of the tasks. Data will be used for academic research purpose only and will be securely kept for the stipulated timeframe, currently five years, after which it will be destroyed. Note that you have the right to withdraw from this study anytime without any negative and undesirable consequences to yourself.

(Should you agree to participate in this study, please fill in and sign the section below:)

I _____ (Full names - *Optional*), hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Signature _____ Date: _____

(Optional:) Surname: _____

Name: _____ Student number: _____

Thank you for taking part in this research.

Appendix 5: Usability evaluation questionnaire

QUESTIONNAIRE: FOR USER INTERFACE SATISFACTION

There are 5 sections to this questionnaire. Indicate your response by selecting the relevant statement.

Section 1: Ease of use

	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
1.1 Language used is easy to understand	5	4	3	2	1
1.2 Words used are similar to words that I am used to	5	4	3	2	1
1.3 It is easy to read words on the screen	5	4	3	2	1
1.4 It is easy to understand pictures on the screen	5	4	3	2	1
1.5 It is easy to follow the way information is arranged	5	4	3	2	1
1.6 It is easy to see options I have selected	5	4	3	2	1

Section 2: Efficiency

2.1 When I make a mistake I get a clear message	5	4	3	2	1
2.2 The EXITs are clearly marked in case I need to exit the screen	5	4	3	2	1
2.3 The screens look similar and are easy to follow	5	4	3	2	1
2.4 Users with little computer experience can use this system	5	4	3	2	1

2.5 The system is designed for all levels of users	5	4	3	2	1
--	---	---	---	---	---

Section 3: Effectiveness

3.1 The instructions on what to do are clear	5	4	3	2	1
--	---	---	---	---	---

3.2 I can see the next option to click	5	4	3	2	1
--	---	---	---	---	---

3.3 It is easy to see the HELP documents	5	4	3	2	1
--	---	---	---	---	---

Section 4: Easy to remember

4.1 The screen layout makes it easy to remember	5	4	3	2	1
---	---	---	---	---	---

4.2 The words used when I make a mistake help me to learn	5	4	3	2	1
---	---	---	---	---	---

Section 5: Satisfaction

5.1 I am satisfied with the way the system works	5	4	3	2	1
--	---	---	---	---	---