USABILITY EVALUATION OF AN E-LEARNING TUTORIAL USING TWO EVALUATION METHODS

by

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submitted in accordance with the requirements
for the degree of

MASTER OF SCIENCE

in the subject

INFORMATION SYSTEMS

at the

UNIVERSITY OF SOUTH AFRICA

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June 2012

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I declare that USABILITY EVALUATION OF AN E-LEARNING TUTORIAL USING TWO EVALUATION METHODS is my own work, and that all sources used or quoted in the study have been indicated and acknowledged by means of complete references.

Julius Omondi Nyang'or **Date**

ABSTRACT

The use of interactive e-learning tutorials is an effective form of teaching and learning. It is therefore important that attention is paid to their usability. This research relates to the evaluation of a CD-based e-learning tutorial for learning Business English, with the aims of investigating its usability and identifying problems. Particular attention is paid to aspects that hinder the learner from achieving the learning objectives. The study uses two usability evaluation methods (UEMs), namely controlled usability testing in an HCI laboratory and a user questionnaire survey. The main aim of the study is to compare the findings and determine the impact of using two methods in combination.

The first outcome of the research was a synthesized framework of evaluation criteria that was applied in the two UEMs. Secondly, findings of the evaluations indicated that the two UEMs identified similar problems, thus confirming their reliability in usability evaluation. Another finding was instances where one method produced results not obtained by the other, which shows the complementary value of two different UEMs. A third benefit of the study was that it identified usability problems in the target system.

Key terms:

E-learning; electronic tutorials; evaluation criteria; human-computer interaction; questionnaire survey; usability evaluation methods; usability testing.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor Prof. M.R. De Villiers, for providing me with world-class supervision and the co-supervisor Mr S. Ssemugabi, for the team spirit throughout this study. Their encouragement, support and inspiration in this exciting field of human computer interaction (HCI) has surely shaped my interest in research. Their tireless efforts have seen me through this study and I pray that they keep up the spirit of providing research leadership.

Special thanks to Mrs Sheyne Ball for her meticulous language editing that was always carried out promptly.

I also convey my special thanks to Mr Obadiah Kibara and his family for the hospitality during my visits to Pretoria and encouragement during my studies.

To all the staff members at UNISA who were the participants in the usability testing studies and/or facilitated this research, I am very grateful for your invaluable support. I would also like to thank the participants in the user questionnaire survey for valuable data and ensuring the high number of responses.

To all of you, may Almighty God bless you abundantly.

With love to my wife Sylvia, my son Ferdinand, my daughter Adelaide and to my parents Joseph (RIP) and Francisca.

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Chapter 1: Introduction and overview

1.1 Introduction

Text books and teachers' knowledge and skills have traditionally been widely used as the main sources of knowledge for learning, usually in the context of conventional classroom learning (Visser & Visser, 2002). This paradigm formed the foundation that influenced other modes of learning as technology first began to impact upon instruction and learning. However, it is essential that new forms of teaching and learning are designed and implemented in ways that optimise their use in their own right, rather than merely transferring earlier approaches to electronic modes.

Educational computing began to come into its own in the 1980s. With the advent of the microcomputer, the concepts of learner-controlled systems and computer-based instruction (Alessi & Trollip, 2001) became increasingly common. However, newer information technologies have provided fuller opportunities to develop learner-centred, interactive, engaging and easily distributed learning environments (El-Tigi & Branch, 1997; Khan, 2002; Visser & Visser, 2002). For instance, the development of the Internet revolutionised communication and provided new opportunities for delivering instruction (Starr, 1997). In addition, from the 1990s the World Wide Web (WWW) extended the classroom virtually, by making information available at different connected sites (El-Tigi & Branch, 1997). However, these developments have come with associated challenges. The emerging challenges can no longer be attributed merely to lack of technical skills but also to issues of computer interface design and user interaction (White, Wright & Chawner, 2006).

A study by Muilenburg and Berge (2005) determined that a significant number of learners expressed lower satisfaction with the e-learning applications than with conventional classroom learning. This could be due to the fact that some emerging solutions use piecemeal approaches instead of offering all-inclusive solutions (Conlon, 2008). Furthermore, some educational applications do not offer upfront information to the users (learners, authors and educators) about the system's content and capability (Aroyo & Dicheva, 2004; Zaharias, 2006). This makes it difficult for the users to determine if their current needs and goals can be satisfied by such systems, which may result in inappropriate products being used. In this context, Ardito, Costabile, De Marsico, Lanzilotti, Levialdi, Roselli and Rossano (2006) call for learner-centred design (LCD) that addresses different categories of learners based on their learning strategies, motivation and experiences.

Based on this introduction, Section 1.2 discusses the problem statement, followed by Section 1.3 which presents the goals and intended value of this study. The research questions are presented in Section 1.4. The scope of the study that includes domain, limitations, delimiters, assumptions and decisions is discussed in Section 1.5. Section 1.6 is about the design of the study giving a graphical presentation of the chapters and their relationships to each other. The chapter is concluded in Section 1.7.

1.2 Problem statement

Educational applications should have interfaces that simplify communication with the users. The approach in the design of e-learning should be toward developing usable systems. *Usability* of a system is defined as the extent to which it can be used by intended users to accomplish the intended goals with effectiveness, efficiency and satisfaction in an intended context of use (Dix, Finlay, Abowd & Beale, 2004; ISO 9241-11, 1998; Preece, Rogers & Sharp, 2007). Usability mainly focuses on how the system supports user interaction through appropriate and meaningful interfaces and supportive navigation. The design and implementation of any system should be focused on the users' needs. Barnum (2002) points out that quality assurance, zero defects, utility of design features and other essential features in a product do not constitute usability. The conventional requirements analysis (in the software development life cycle) helps to bring out functional requirements geared towards the users and their goals. These functional requirements can be addressed in the development by engaging user groups to test a system to explore the implementation of initial goals. In this way, software developers can determine whether the goals have been achieved and to what levels of efficiency. Such feedback from users does help to improve the application's efficiency.

However, testing of the functionality does not constitute usability evaluation. Users may experience difficulties in effective use of the software. Attention should not be focused on achieving *functionality* at the expense of *usability*. The problem of not addressing usability aspects in a software project becomes more complex if the developers lack usability evaluation skills. In this regard, there is a need to create an understanding of what is usability, and what is not, throughout development. A usable system should have consistency between interfaces, must avoid elements that might distract learners, and provide simple navigation and orientation. Such features help learners to be at ease with the system and not to view the underlying technology as a barrier to learning (Ardito *et al*., 2006). Usability of e-learning systems should provide the type of interactivity that promotes ease of learning and offers meaningful engagement with the content (Masemola & De Villiers, 2006). Fundamentally, it is essential that the design of e-learning systems should take into account both principles of instructional design and interaction design.

To achieve this, products should undergo evaluation and subsequent refinement. This calls for application of adequate and appropriate *usability evaluation methods (UEMs)*. These methods assist evaluators to identify usability problems that need to be addressed through design and redesign of a system (Furniss, Blandford & Curzon, 2007). In particular, the use of more than one UEM for usability evaluation fosters reliability of the results and credibility of the findings. Hence, this master's degree research is a study of the application of two different UEMs, namely usability testing and a user questionnaire survey, in evaluating an e-learning tutorial. It is a meta-evaluative study that compares the findings of the two, and considers the effectiveness of using two methods in combination.

In order to undertake any study of usability evaluation, a target application is required to provide a case study environment in which to do an evaluation. In this case the target application system is *Instap!E4B*, which is an offline CD-based interactive software application for learning English as a language for use in business by candidates who have completed secondary education. *Instap!E4B* is described and illustrated in Chapter 5. The researcher chose usability evaluation as the topic for his MSc study, and requested advice from his supervisors on a suitable target system to evaluate. Initial options were two of the interactive CD-based tutorials developed by, and used in, the School of Computing at the University of South Africa (UNISA). These, however, had been or were being evaluated by other researchers. For example, the tutorial *Karnaugh*, which offers supplementary learning material for the first-level module, *Computer Systems: Fundamental Concepts*, was the object of an evaluation study by Becker and De Villiers (2008) and a subsequent evaluation by Adebesin, De Villiers and Ssemugabi (2009). A further possibility was the tutorial, *Relations*, which offers supplementary material for a complex section of a UNISA first-level module, *Theoretical Computer Science 1,* but this had been extensively evaluated (de Villiers, 2004; Masemola & De Villiers, 2006; De Villiers, 2007b). On further enquiries, the e-learning tutorial, *Instap!E4B*, was identified as being a suitable target system for the case study. *Instap!E4B* is part of the '*MULTITAAL*' series, developed and produced outside UNISA. It was suggested by a senior member of UNISA academic staff, who knew the designer of *Instap!E4B* and had had a minor involvement in its development. This provided new territory for an evaluation study and, furthermore, it had not been evaluated before. The designer-developer, Prof. Dr Lut Baten was approached and was most happy for it to be used. She provided a CD and requested that findings of the evaluation be made available to her, which will be done on successful completion of the research and the MSc degree. The system was therefore used with kind permission from Prof. Dr Lut Baten. Her full approval was given from the outset and a formal authorisation was acquired to include in this document – see Appendix A-I.

1.3 Goals and value of the study

Increased diversity of learners, technological advancements and the dynamic nature of learning tasks have made usability evaluation of e-learning applications a major task, which plays an important role in improving the quality of such applications (Zaharias, 2006). The background provided in the problem statement in Section 1.2 sets out the need for this research. However, it is important to justify and ground the research further by referring to the identification of appropriate approaches to the usability evaluation of e-learning applications, as distinct from usability evaluation of traditional task-based systems. Masemola and de Villiers (2006) consider what is actually meant by 'usability' in the context of learning environments and point out some unique aspects of interactive e-learning applications:

- They are focussed more on a process (the learning process) than on a product.
- Rapid task completion is not necessarily a 'good' measurement, because users have different learning styles and approaches.
- There should not always be an emphasis on minimizing errors. System-related usability errors should be identified and corrected, but cognitive content-related errors (Squires & Preece, 1999) can be part of the learning process.

Effective usability evaluation of e-learning requires applying appropriate evaluation criteria and evaluation methods. With regard to *criteria*, sets of criteria (also termed heuristics) customised for evaluating e-learning applications or educational multimedia, are presented by Albion (1999), Alessi and Trollip (2001) and Ardito, Costabile, De Marsico, Lanzilotti, Levialdi, Roselli and Rossano (2006). These criteria address pedagogical and content-related aspects, as well as conventional aspects of usability. With regard to *methods*, the seminal work of Ardito et al. (2006) mentions the value of methodologies that combine user-based evaluation with an inspection method undertaken by expert evaluators. Research conducted at UNISA has also confirmed the worth of using two or more UEMs for evaluating e-learning applications (De Villiers, 2007b; Ssemugabi & de Villiers, 2010).

The primary goal of this study is therefore to investigate the impact of using two UEMs to identify usability problems in an e-learning tutorial. This study determines the effectiveness of using two UEMs in combination, namely controlled usability testing in a laboratory and a questionnaire survey among users, instead of using only one UEM, to evaluate the usability of an e-learning tutorial.

The research will contribute to the general body of knowledge of usability evaluation of e-learning. The findings should be useful both for formative evaluation of e-learning applications that are under development and for summative evaluation of existing ones.

Further benefit comes from the evaluation of the target system, *Instap!E4B*, but this is not the primary goal of the study. The findings should, however, be useful to the designers of *Instap!E4B* in their future development efforts.

1.4 Research questions

The research design of this study is discussed in detail in Chapter 6. In particular, the study addresses three Research Questions, two of which have sub-questions:

1. What are appropriate criteria for evaluating an e-learning tutorial?

2. What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on *Instap!E4B*?
   - What usability and learning problems in *Instap!E4B* can be identified from evaluation by a user questionnaire survey?
   - What usability and learning problems in *Instap!E4B* can be identified from evaluation by usability testing?

3. How effective is the use of more than one evaluation method to identify learning and usability problems in an interactive CD-based e-learning tutorial?
   - How do the results and the findings of the two usability evaluation methods (UEMs) compare?
   - Does the dual approach to evaluation enrich the findings?
   - Do the findings contribute to meta-evaluative knowledge in the context of usability evaluation of e-learning?

1.5 The scope of this study

1.5.1 Domain of the study

The study relates primarily to usability and learner-centred design in educational applications. It is approached from a theoretical foundation, based on a review of various existing literature sources. In a dual evaluation approach, a user questionnaire survey and usability testing are the evaluation techniques applied in the study. The two selected UEMs are discussed in detail in Chapter 6. Both evaluations are conducted with end-users, namely learners, as participants with the aims of investigating usability and identifying learning problems and usability problems encountered in the target system. Learning problems are didactic challenges in the system that impede acquisition of knowledge (De Villiers, 2005). The findings of these empirical studies are presented and discussed in Chapter 7.

1.5.2 Limitations and delimiters

As previously stated, this evaluation is conducted on *Instap!E4B* as the target system. It is an interactive CD-based e-learning tutorial for learning Business English, and is used to supplement other forms of learning the required language skills.

The evaluation criteria developed for the evaluation are focused on aspects such as learner-centred design, the learning content and activities, error recognition and feedback, navigation and interactivity, and the identification of problems in the e-learning application evaluated.

Different samples of participants were used in the two studies. The user survey was conducted in 2010 in the researcher’s home country, Kenya. The usability testing was conducted in the Human-Computer Interaction (HCI) laboratory at Unisa’s School of Computing in 2011 during a visit by the researcher to the UNISA Muckleneuk Campus in Pretoria.

1.5.3 Assumptions and decisions

It was assumed that the users (learners) were adults who could communicate in English and who were interested in learning the use of the English language for business purposes.

It was decided that the participants selected for the usability testing research should be computer literate and at least on the level of tertiary studies. Reading system instructions and understanding the tasks on the task list would, therefore, not be complex for them.

Similarly, it was decided that the participants in the questionnaire survey should be computer literate and at least on a tertiary level of studies. It was also assumed that the sample among whom the questionnaire was administered would not compromise the research findings.

Research in an HCI laboratory involves the use of sophisticated equipment and requires the availability of a skilled facilitator who also has technical expertise. Using such facilities is costly but, as a postgraduate student of the University of South Africa (UNISA), the present researcher was able to use the laboratory in UNISA’s School of Computing in Pretoria free of charge. Moreover, the questionnaire survey is an inexpensive evaluation method.

Both the user survey and the usability testing sessions had to be completed within a reasonable duration to optimise the available time with the participants. It was therefore anticipated that, with each of the two methods used, a user should complete a session within one hour.

1.6 Research design and methodology

1.6.1 Introduction

This study used two usability evaluation methods, usability testing and user survey, in each case the main study was preceded by a pilot study. The pilot usability testing used four participants, which is within the range of three to five participants, as recommended by Nielsen (1994a). Nielsen (2000) suggests that adding more participants than five is unlikely to identify new usability problems. In the main usability testing study, 12 participants took part in usability testing sessions. In the user questionnaire survey eleven participants were used in the pilot learner survey completed the questionnaire while 50 participants in the main study.

In a case study approach (Gillham, 2000a; Olivier, 2009), a single case design was used by conducting in-depth evaluation on a single target application, namely *Instap!E4B*, i.e. a real-world object was investigated. Multiple evidence was obtained by using dual evaluation methods and triangulation to assess the usability and to identify usability problems, providing qualitative and quantitative data. The findings of the two methods were then compared. The case study methodology is described in more detail in Section 6.2.

The sections that follow briefly present the research design, proposed chapters and the structure of the study.

1.6.2 Research design

This research design was driven by the research problem presented in Section 1.2. This research focuses on usability, with special reference to usability evaluation of e-learning applications. As stated, it employs two usability evaluation methods, a user-based survey and formal usability testing, to identify usability problems in *Instap!E4B*. By using two UEMs, the study aims to determine whether the dual approach enriches the findings and whether it would be an appropriate methodology for evaluation of other systems.

The research design and the procedures that are briefly introduced in this chapter are presented in detail in Chapter 6. To undertake the study, the researcher needed a research method or methods and appropriate evaluation criteria. The Research Questions listed in Section 1.4 led to the generation of evaluation criteria presented in Chapter 4, which were based on concepts that had been encountered in the literature surveys on usability of e-learning applications (see Chapters 2 and 3). These criteria pinpointed important factors to be investigated in this research. The evaluation criteria, in turn, led to usability testing tasks and sets of questions to be answered in the two empirical studies. For the questionnaire survey, the criteria were converted to the form of exploratory questions and, for the usability testing, they were used to help the researcher define tasks to be conducted by participants during the sessions.

The user survey gathered both qualitative and quantitative information (Mouton, 2008; Olivier, 2009). Usability testing provided quantitative data from the controlled environment of the evaluation (Mouton, 2008). In this case, data collection involved taking measurements, called usability metrics. Ideally the testing should be carried out on a small sample of real users (Mouton, 2008; Olivier, 2009), but in this research, a sample of UNISA students similar to the typical intended users of *Instap!E4B* was used.

1.6.3 Proposed chapters of the dissertation

The chapters of this dissertation are as follows:

- Introduction and overview
- E-learning and learning theories
- Usability evaluation of e-learning applications

- Criteria and framework for usability evaluation of e-learning applications
- The target application: *Instap!E4B*
- Research design and methodology
- Data collection and analysis and discussion of results
- Conclusions and recommendations.

1.6.4 The structure of the study

This study consists of eight chapters as mentioned above. Brief descriptions of what the chapters contain are presented after Figure 1.1.

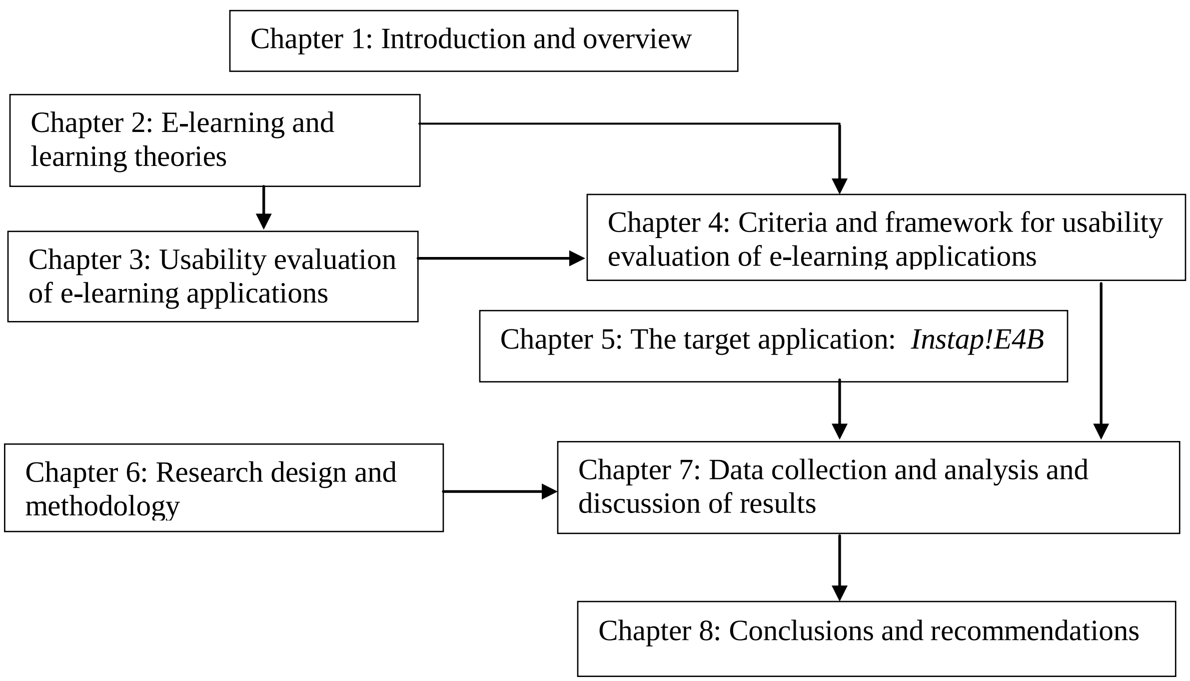

Figure 1.1: Structure of the study

The introduction in Chapter 1 overviews the research problem and the purpose of the research. It outlines the intentions of the entire study, presents the research questions, the rationale for the study, and the approaches used to achieve the objectives.

The second chapter is a major literature review of e-learning and how it relates to learning theory. The chapter gives a broad view of e-learning with mention of how other forms of e-learning relate to offline e-learning such as stand-alone tutorials. The material serves to identify criteria that are appropriate for evaluating interactive e-learning tutorials. Chapter 2 therefore contributes to answering Research Question 1.

In Chapter 3, the discussion is about usability and usability evaluation of e-learning systems. This chapter considers different aspects of usability and, in particular, the usability of e-learning applications. This chapter forms a strong basis for developing criteria for evaluating stand-alone interactive e-learning tutorials, such as the target system used in the study. The discussions in this chapter and in Chapter 2 contribute towards answering Research Question 1. Chapter 3 also contributes to answering Research Question 2 in Sections 7.2, 7.3 and 7.4.

Chapter 4 uses the literature sources in the preceding two chapters to synthesise a framework of criteria for this usability evaluation. These criteria should have relevance to both usability evaluation methods applied in this study. This chapter thus answers Research Question 1 in Sections 4.4 and 4.5.

In the fifth chapter, the target application, *Instap!E4B*, is presented by describing its various interfaces and *functions*. The chapter sets the context of the case study and plays a role in answering all the Research Questions.

The sixth chapter sets out the design and methodology for the research. It outlines how the empirical studies will proceed and Table 6.1 shows where each research question is answered. The selected UEMs, questionnaire survey and usability testing, are outlined. This chapter is closely connected to Chapter 7, which deals with the empirical evaluations of *Instap!E4B* tutorial using the two UEMs. The design and methodology in Chapter 6 assist in answering all three Research Questions.

Chapter 7 presents a case study on the dual-method evaluation of *Instap!E4B* and analyses the results of the empirical studies using the two different UEMs. In its analysis, it compares the two sets of findings and the problems identified in the two studies. It also discusses and compares the effectiveness of the two UEMs in evaluating the target application. This chapter answers Research Questions 2 and 3 in Sections 7.2, 7.3, 7.4 and 7.5.

The eighth and final chapter provides a conclusion to the study, recommendations, and areas for future research.

1.7 Summary and conclusion

There is a need for educational systems to address the vital issues of learning content and interaction that are fit for purpose. Sections 1.1 and 1.2 showed that the design and use of e-learning systems should take instructional and interface design principles into account. Furthermore, a good interface, sound usability and appropriate design of educational and learning aspects contribute to effective educational software.

It is important to clearly set the goals and value of the study (see Section 1.3) based on the problem statement. In this case the chapter identified the effectiveness of using two UEMs in combination for usability evaluation of a learning system as the main goal. Based on the study's goal, the chapter formulated the research questions in Section 1.4. The research questions are to be addressed and answered in later chapters within the scope of this study as presented in Section 1.5.

The chapter culminated in Section 1.6 by presenting the design of the study, including the literature surveys, discussion of the target system and analysis of the usability evaluation data.

Chapter 2: E-learning and learning theories

2.1 Introduction

There has been a rapid growth in the use of educational software applications – currently referred to as e-learning – developed to complement or replace classroom learning. This chapter provides a broad overview of various forms and methodologies of e-learning, as well as addressing factors related to their development and delivery. It is essential that new forms of teaching and learning are designed and implemented in ways that optimise them in their own right. The material in this chapter also serves as a basis for criteria that are appropriate for evaluating interactive e-learning tutorials. The chapter thus contributes towards answering Research Question 1.

There is an important relationship between underlying learning theories (also called learning paradigms) and the implementation of e-learning. Different educational applications have varying purposes and approaches, and are correspondingly based on different learning theories.

The chapter commences in Section 2.2, by outlining the three main current learning theories: behaviourism, cognitivism and constructivism. E-learning, in and of itself, is considered in Section 2.3. The section presents the definitions of e-learning and the main features of e-learning systems. Section 2.4 is about different forms of e-learning and methodologies. It mainly covers CD-based learning tutorials and the learning management systems that are used to facilitate e-learning. In Section 2.5, the discussion is about components and the characteristics of e-learning. Section 2.6 presents the issues that are associated with production of e-learning systems. The challenges in e-learning are discussed in Section 2.7. E-learning as a mechanism for delivering learning is discussed in Section 2.8 where it looks at distance learning and blended learning. Section 2.9 discusses the role of instructional design in e-learning. The chapter is concluded in Section 2.10.

2.2 Learning theories

The processes of designing, developing and evaluating educational systems require one to reflect on whether they appropriately reflect underlying theories of learning (Alessi & Trollip, 2001). Contemporary educators have proposed various sets of principles and theories of learning. This section discusses the three main current learning theories: behaviourism, cognitivism and constructivism, based on principles of behavioural psychology, cognitive psychology, and constructivist psychology, respectively (Alessi & Trollip, 2001). Attention is also paid to the Hexa-C Metamodel (De Villiers, 2005; De Villiers, 2007a) which combines various current learning theories and practical methods in a single model.

Behaviourism views learning as changes in the observable behaviour of the learner in response to events and stimuli in the environment. Behavioural psychology views learners as being largely passive (Alessi & Trollip, 2001). Knowledge should be imparted to learners by educators, printed material, and electronic learning resources. *Cognitivism*, by contrast, is a stance that considers the information processing capability of human beings. Learning is considered to occur due to cognitive constructs such as mental processing, comprehension, memory, integration of new information with prior learning, and motivation. The *constructivist* approach maintains that knowledge is constructed within an individual and that learners make personal interpretations as they learn (Alessi & Trollip, 2001).

2.2.1 Behavioural psychology

The principles of behavioural psychology view learning as the acquisition of a certain behaviour or set of behaviours, in order to meet particular needs (Alessi & Trollip, 2001). This psychological paradigm commenced early in the 20th century when Ivan Pavlov conducted research based on classic operant conditioning. He noted that a dog salivated (as a basic instinctual response to a natural stimulus in the form of food) when a bell was rung, and thus it became a conditioned stimulus. Repeated pairing of a neutral stimulus with a natural stimulus caused the dog's response. In the context of human beings, this involves pairing behaviour with basic human needs in a stimulus-response approach. In the context of e-learning, De Villiers (2005) suggests that the didactic approach to learning is an implementation of behavioural psychology, based on predefined objectives and the transfer of information to learners in the form of instructional transactions.

Another foundation is Skinnerian behaviourism that involves the study of observable behaviours and that emphasises inter-related events in the learning environment. Observable behaviour refers to learners' responses and activities that can be tangibly perceived by others, in contrast to unobservable constructs such as memory, attitudes, thinking and other internal processes (Alessi & Trollip, 2001). Behaviourism is epitomised by the stimulus-response-reinforcement paradigm, where learners are largely treated as passive recipients of information. Positive reinforcement involves 'rewarding' required behaviours and this usually increases the frequency of such behaviours. In contrast, a negative result or 'punishment' decreases the frequency of a behaviour (Alessi & Trollip, 2001; De Villiers, 2005).

The development and design of many instructional technologies originate from behaviourism. Black (1995) mentions teaching machines and computer-aided instruction (CAI) as examples. Teaching machines use linear and/or branch design methods in creating self-paced delivery of instruction. Typical examples of behaviourist CAI are drill-and-practice software which offer exercises in basic skills. When learners provide correct answers to questions, they are rewarded with so-called positive reinforcement, which encourages them to respond in similar ways in future occasions (De Villiers, 2005).

It is important to note some of behaviourism's shortcomings. Alessi and Trollip (2001) point out that it ignores vital unobservable learning features, for example, thinking, reflection, memory and motivation. Moreover, it is primarily focused on educators and instructional material, at the expense of learners.

2.2.2 Cognitive psychology

The principles of cognitive psychology are based on unobservable mental constructs such as learners' memory, attitude, motivation, metacognition, reflection, and other internal processes. Unlike observable behaviours (Section 2.2.1), these mental changes cannot be seen by others (Alessi & Trollip, 2001). Cognitivism is characterised by a didactic and exploratory approach to learning (De Villiers, 2005). The so-called *human information-processing* approach suggests that human beings learn by using their senses to acquire information. As they perceive information, they should receive it and store it for future retrieval. It is important that learners are able to integrate new learning with previous knowledge. Another theory of cognitive psychology is the *semantic network representation* (Alessi & Trollip, 2001). It is based on the claim that the brain is comprised of billions of inter-related cells, with multiple connection points (nodes) and links that form the connections. The theory proposes that cognitive activities (thinking, remembering, acting and problem solving) take place at the information nodes. While some e-learning tutorials are mainly behaviourist, others use cognitive principles and activities that require learners to apply critical thinking skills.

2.2.3 Constructivist psychology

The principles of constructivist theory propose that knowledge is personally constructed and interpreted in learners' minds rather than being received from outside (Alessi & Trollip, 2001). The emphasis is on active learning rather than teaching, thus it supports the learner in ownership of his/her learning processes (Alessi & Trollip, 2001; Bruner, 1990). Learning environments should provide multiple knowledge representations that enable learners to explore their surroundings. Constructivism involves open-ended, flexible and exploratory learning in authentic contexts that encourage learners to construct knowledge personally (De Villiers, 2005). This contrasts with the objectivist world-view that there is a single objective reality and that instruction should assist learners to correctly absorb, interpret and operate within that view (Alessi & Trollip, 2001). The different ways in which knowledge is constructed by individual learners results in alternative approaches to interpretation and procedures.

Due to the constructivist principle that learning is the process whereby learners actively construct knowledge, traditional instructional methods (memorising, demonstrating and imitating) are seen as incompatible with this view (Alessi & Trollip, 2001; Reigeluth, 2011). Constructivists encourage designers of learning environments to create environments and situations that are conducive to participative construction of knowledge, and that ground learning activities in authentic, real-world contexts. Discovery learning and guided-discovery approaches can help learners to generate and construct personal learning content; collaborative learning activities are an important feature. Learners should review and reflect on the knowledge they acquire and take personal ownership of learning activities. Concepts should not be over-simplified, but should be illustrated by requiring learners to do contextualised tasks that are personally relevant,

In line with the above, it is evident that constructivist psychology supports scaffolded, and not tutored, learning (De Villiers, 2005).

2.2.4 Learning theories and Hexa-C Metamodel

The Hexa-C Metamodel (De Villiers, 2005) is a synthesis of contemporary learning theories and existing models, hence it is termed a metamodel. Its six inter-related elements are relevant to the design and development of e-learning environments and instructional systems, and can also be used in evaluating educational applications from the perspective of learning theory. The six elements are:

- Cognitive learning theory,
- Constructivism,
- Components,
- Creativity,
- Customisation, and
- Collaborative learning.

In this model, cognitive learning theory, constructivism, and components, are essentially theoretical in nature, whereas creativity, customised learning, and collaborative learning are practical means that educators use to foster effective and affective learning (De Villiers, 2005; De Villiers, 2007a). Its elements are considered as segments that merge around the hub of technology. Technology is considered to be a transfer mechanism for messages, but not the message itself. Contextualisation is essential, emphasising that the nature of each e-learning artefact or environment should be determined by its content and situation. It is not the intention that any single e-learning application should conform to all six C's, but rather that designers should pay cognisance to the metamodel as a design aid and consider which element/s are relevant as foundations to the situation in hand.

2.3 E-learning

E-learning has become an integral part of modern learning and encompasses varying types of e-learning applications currently in use. This section introduces various definitions and features of e-learning.

E-learning applications are expected to readily support the learning process and should be easy to use (Adebesin *et al.*, 2009). It is important that the interaction interfaces of learning systems support the learners' understanding of the intended concepts (Pardo, Vetere & Howard, 2006) and this vital aspect will be considered in the next chapter, Chapter 3, which is dedicated to usability and usability evaluation.

2.3.1 Definition of e-learning

E-learning can be viewed as a virtual extension of classroom learning through information made available at different locations (El-Tigi & Branch, 1997). There are varying definitions of e-learning. Some definitions relate only to the use of the Internet and networks for design, delivery and management of instruction and learning (Masie, 2008; Rosenberg, 2001). Other definitions are broader such as that of Balasundaram (2011) who describes e-learning as means that facilitate and enhance the teaching and learning process by use of appropriate tools and technologies. Clark and Mayer (2003:13) define e-learning as "instruction delivered on a computer by way of CD-ROM, Internet, or Intranet". Romiszowski (2004) makes reference to the *learnativity* website in describing e-learning as the unification of online learning with web-based training or technology-based training. The definition of e-learning has thus been expanded to include instructional delivery through multiple formats, hybrid methodologies and a variety of electronic learning experiences such as interactive tutorials, simulations, educational games, multimedia CD-ROMs, online courses and audio/video tapes, as well as the Internet, intranets and web-based learning (Catherall, 2005; De Villiers, 2005; Hung 2012). The broader definitions are relevant to this study, which uses as target system a CD-based tutorial.

Khan (2002) defined eight "dimensions" of e-learning, namely the pedagogical, ethical, managerial, institutional, interface design, ethical, resource support and technological dimensions. Khan points out that, if used effectively, technology can support e-learning that is learner-centred, well-designed, interactive, easily accessible, flexible and meaningful, all of which can enhance learning. Furthermore, El-Tigi and Branch (1997), writing in the early days of web-based learning, recommend that regardless of the location, an e-learning (or learning) session should, in principle, include the following:

- learners' interaction with the educators,
- learners' control over the learning information, and
- a feedback mechanism to inform the learners about their learning status.

If correctly applied, these recommendations can be pillars of effective instructional design and successful e-learning. In this way, e-learning fosters learner *interaction* with technology (Romiszowski, 2004), rather than using technology for one-way transfer of knowledge.

2.3.2 Features of e-learning applications

E-learning is characterised by various features, or properties, that may be manifested in different ways. These include, among others: online and offline technologies; synchronous or asynchronous learning; and collaborative or isolated learning. Some of these properties are considered in this section.

2.3.2.1 Online/offline technologies

In an *online* form of e-learning, there is connectivity to the Internet or an intranet, and this can facilitate either synchronous or asynchronous interaction formats. For *offline*, the material is often available on a CD-ROM and the learners can access its content locally at their individual computers. In educational institutions, the offline features of learning can be loaded in file servers or data servers, so that the learners can access them at different locations.

2.3.2.2 Synchronous/asynchronous communication

In *synchronous* e-learning, there is real-time contact between the learners and the educator/facilitator or peer-to-peer communication between learners, such as in a *chat* session. Such contact is crucial for supporting the collaborative features of learning. On the other hand, *asynchronous* features operate via formats such as e-mail. This implies that the other learners and/or educators can respond at their convenience. It is appropriate for situations when some participants are unavailable when others are online. The learners who were unavailable at that point in time can respond to previously posted requests and instructions when they, in turn, are online. It must be noted that not all applications offer communication facilities, but where it is possible, it is either synchronous or asynchronous as defined above.

Examples of synchronous communication are chat rooms, multi-user domains (MUDs), and video- or audio-conferences, while means of asynchronous communication include e-mail, newsgroups and bulletin boards (De Villiers, 2005). Synchronous web-based collaboration platforms can help to nurture learner brainstorming and questioning, presenter elaborations and clarifications, role-play and one-to-one mentoring (Bonk, 2002). Other synchronous training tools are breakout rooms, polling, file transfer and discussion boards. Social networking offers a new form of communication that can be used synchronously or asynchronously. Warren (2003) adds that collaboration and communication (either synchronous or asynchronous) can occur via a shared whiteboard on which learners can post contributions.

2.3.2.3 Purpose of the application: didactic/administrative

Another important feature relates to the purpose of the e-learning application. For *didactic* purposes, there may be actual electronic teaching of learners, for example: conveying of instructions; diagrammatic explanations; provision of exercises at the end of a topic; interactive learning activities; and learning from the system's examples or demonstrations. Many interactive tutorials serve didactic purposes. On the other hand, there are systems that include the *administrative* functions of e-learning, such as: uploading of study material; submission of work by learners; online test-taking; grading and record keeping; and online registration for courses and events. Learning management systems incorporate these monitoring and administrative functions. The aspects mentioned in this section will be addressed in more detail in later sections.

2.4 E-learning forms and methodologies

Technologies have emerged leading to e-learning applications in multiple forms and methodologies and conveyed on multiple media. Some of these media are fixed and stand-alone, while others are dynamically networked, delivering learning resources on the Internet or by dedicated intranets. This section addresses various forms of e-learning and their respective purposes. It commences by describing some forms of e-learning that originated as 'computer-assisted instruction' but that are still entrenched. It then moves on to address methodologies such as web-based learning, multimedia technologies and learning management systems.

2.4.1 Computer-assisted instruction (CAI)

Computer-assisted instruction (CAI) is one of the original terms, common in the 1980s and 1990s for the phenomenon of learners interacting with computers to acquire knowledge, but still in use for some offline forms of e-learning. CAI content pre-dated the Internet and tends to be rigid in nature, although new content and modifications may be included in updated versions (Liu, 2001). CAI should provide feedback to the learners from which they can identify their weaknesses and competencies when compared to the learning outcomes. As systems that are used for learning, CAI should be designed so as to make learners think (Mayes & Fowler, 1999).

In contact teaching and in distance learning, computer-assisted instruction and web-based learning can be used alongside other modes. The use of CAI is not intended to replace skilled educators or other learning materials in assisting the learners to master the necessary intellectual and motor skills (Averill, 2004). They should instead be viewed as complementary efforts. When conventional class-based learning is supplemented with electronic forms, it is termed blended learning (see Section 2.8.1).

Well-known forms of e-learning discussed next are tutorials, drills, and simulations, all three of which originated as CAI systems.

2.4.2 E-learning tutorials

Interactive electronic tutorials are designed in the typical CAI format, and most of them have behavioural objectives (see Section 2.2.1) that show the intentions for the lesson or learning session (Alessi & Trollip, 2001). A typical tutorial as defined by Alessi and Trollip (2001) includes the following sections and features:

- Introductory section,
- Presentation of information,
- Questions and responses segment,

- Judgement of responses,
- Feedback and remediation,
- Learner control, and
- Help.

These concepts are now explained.

Introductory section

Tutorials frequently have behavioural objectives of guiding learners into what is expected of them, that is, what should be accomplished by the end of a learning session. They need to attract the learners' attention. It should also have directions that are suitable for different categories of learners. In most cases, people learn more when they relate to what they already know, in comparison to completely new information they encounter. In such situations, Alessi and Trollip (2001) recommend that an introduction should test:

- whether the learner is ready for the particular learning session using the system,
- whether the learner is starting the session at the appropriate point, and
- whether the learner has prior knowledge that can be of use to the learning, that is, how much do they already know?

This pre-testing can also assess prerequisite knowledge and final objectives.

Presentation of information

The information should be presented to learners in ways and formats that aid them in achieving the learning objectives. Text should be supplemented with graphical presentations and possibly also with sound and video. The material should be interactive and have clear navigation paths that make it possible to revert to previously accessed sessions. This is important should a learner want to review another topic before proceeding. Teaching segments are described in the next paragraph.

Questions and responses segment

Questions in a tutorial are an important form of interaction with learners. They keep the learners attentive by provision of practice and encouragement of reflection on the intended goals of the assessment. Different formats of the questions, according to Alessi and Trollip (2001), are:

- Alternate response questions
- True-false questions
- Multiple-choice questions
- Matching questions.

It is important that the questions assess recognition rather than recall. They should be easy to understand and should avoid use of abbreviations. Furthermore, use of negative words and cases where a learner has to scroll through the question, should be avoided.

Judgement of responses

This involves evaluation of the responses from the learners, thereafter providing suitable feedback. The judgement can indicate that the learner's response is:

- Correct
- Contains an error of the sort that could be expected
- Is partially correct.

Alessi and Trollip advise that the length of response, time limit, and use of the <Help> and <Escape> options are important considerations in judging responses.

Feedback and remediation

Feedback is essentially the program's diagnostic reaction to learners' responses and can take different formats depending on the system, for example, textual or graphical formats. Various kinds of feedback described by Alessi and Trollip (2001) include:

- Feedback upon use of wrong format
- Feedback to acknowledge a correct response

- Feedback resulting from neutral response
- Feedback resulting from content errors.

Learner control

This enables the learners to have some control of the system that helps them to achieve the learning objectives. It increases flexibility and learning progression pace. Learners should be able to temporarily exit a system and continue from that point later. When such controls are provided, the learners should be able, for example, to review their learning progress, access online help, redo a section. Other optional controls are for the degree of difficulty and the choice of learning strategy (Alessi & Trollip, 2001).

Provision of help

Provision of help supports meaningful learning to take place. When it is procedural help, it is about operating the system and navigating through it, while informational help is about the learning content (Alessi and Trollip, 2001).

Averill (2004) similarly explains that tutorial-based CAI applications are made up of sets of information and instructions to guide learners, interspersed with examples and interactive exercises. Averill stresses the importance of multiple modes of presentation, advocating that CAI lessons should incorporate short textual explanations supported by images, sound data and/or video clips for elaboration. In addition, Averill believes that use of these multiple formats such as sound, video and animation, can help learners to grasp cognitive skills. The interactive exercises should test understanding, and usually include some multiple-choice questions. The system should allow learners to progress to new learning content after demonstrating their understanding of previous units.

This comprehensive discussion on e-learning tutorials is highly relevant, since some of these design features are incorporated in the tutorial *Instap!E4B*, the application used as the target system in this study. Although CAI and interactive tutorials originated more than 20 years ago, they remain relevant and valuable, and are used in current teaching and learning. Current mention of them in use is made by Nkenlifack, Nangue, Demsong and Kuate Fotso (2011) who used e-learning tutorials, along with other resources, for learning and assessment in secondary school computer science education. Similarly in a high school situation, Owusu, Monney, Appiah and Wilmot (2010) compared the efficiency of CAI and conventional approaches in teaching biology.

2.4.3 Drills

Drills (Alessi & Trollip, 2001) are a form of CAI that helps learners in practising skills, in developing fluency, and in retention of learning content. Drill-and-practice CAI enables learners to work through learning tasks and exercises that are similar to each other, until in so-called *mastery learning*, the learners master that type of skill as a result of repetitive practice.

Drills offer different levels of difficulty, depending on the user's performance. They implement a type of learning that can be described as instructivist or objectivist, in contrast to the more open-ended constructivist learning. Although they may be criticised for this, they are very useful in certain situations where practice and fluency are needed, such as spelling and vocabulary in learning a language and in basic mathematical skills (Alessi & Trollip, 2001).

2.4.4 Simulations

Multimedia simulations are models of real-world phenomena or activities. They are an active and motivational form of learning, where users manipulate parameters and thus learn by interacting with the simulation. They can be used for learning that is based on cognitive or constructivist approaches. Simulations may also be combined with games in order to foster discovery learning (Alessi & Trollip, 2001). A further advantage is that simulation applications can be used to teach complex skills and aspects by replicating situations that may be dangerous or expensive – such as chemistry experiments, or that may not have occurred – such as a particular type of solar eclipse.

2.4.5 CAI and its underlying learning theory

Section 2.2 introduced three major learning theories which underlie the various e-learning forms and methodologies. Forms of CAI such as tutorials and drills, introduced in the preceding sections, are often implementations of behaviourism, but can also support cognitivist learning (Alessi & Trollip, 2001).

The learning content and navigational structure of CAI environments should be suitably organised with hyperlinks that direct learners to appropriate paths (Dix *et al*., 2004; Quentin-Baxter & Dewhurst, 1992). The CAI should provide information at a pace that does not impede the learning progress. The knowledge that learners acquire in this way should help them progress to understanding topics that are more complex, but related to the earlier information.

Many of the above-mentioned forms of CAI can be available online or offline. When CAI is used online, its design should be in line with guidelines for web-based learning applications. The next section is on web-based learning.

2.4.6 Web-based learning (WBL)

Web-based learning (WBL) has become one of most common forms of online e-learning. It is therefore vital that it should be characterised by sound usability to facilitate use by the intended learners (Davis & Shipman, 2011). WBL is a medium that integrates learning and teaching (Alessi & Trollip, 2001) and can be used to enhance communication between learners and educators. It can also be used to present some of the different forms of CAI that were explained in the previous section. For example, through WBL, methodologies such as drills or simulations can be delivered to learners. However, WBL comes into its own when it is incrementally and dynamically constructed, constantly being updated by the addition of new content and courses that were formerly unavailable in CAI (Liu, 2001).

The structure of a web-based learning environment should be determined both by the learning goals and by the developers' knowledge base on the subject matter (El-Tigi & Branch, 1997). The next paragraph builds further on these aspects.

The kind of learning that occurs depends on the type of environment and its intended outcomes. Being an online situation, WBL has the potential for input by users, that is, interactive participation from learners (Barton, 2004). In cases where the design enables the monitoring of learners' progress, it is important to identify the learning goals prior to development. Moreover, the team of designers and developers should carefully consider the intended learning content, to help them visualise an appropriate presentation approach for the environment.

Dix *et al*. (2004) emphasise the importance of simple navigation in any website. Similarly, Alessi and Trollip (2001) highlight the importance of good orientation cues and methods of navigation on the Web. They point out the problem of disorientation, particularly in cases where users follow links to other sites on the Web. It can occur that, when learners follow external links and move outside the original WBL environment, they cannot navigate back to the original site.

Although dated, the paper by El-Tigi and Branch (1997) remains a classic approach to WBL. They cite the design model originally proposed by Hackbarth (1996) for WBL. This model has two phases whereby the first phase emphasises the fundamental *interactive components.* Points made by El-Tigi and Branch on interactivity are incorporated below, along with related points from other authors:

1. WBL applications should be designed with features that promote *interactivity* during the learning experience. It is very important to incorporate instructional interaction (Alessi & Trollip, 2001). The interfaces should support learners in attempting exercises or learning activities at the end of learning sessions (Warren, 2003).
2. The most important factor in designing a WBL application, however, is the identification of appropriate *content and skills* to be acquired by learners. Having selected the web content, it is essential to choose presentation and interaction techniques that present this content in the most appropriate and supportive ways (Jonassen, 1999; Kelly, 2004).
3. The design of a WBL application should clearly outline the *purpose* of the site to promote confidence in its objectives.
4. *User control* is vital. Control enables the learners to manage aspects such as the pace of learning and, to a certain extent, the content they access (Alessi & Trollip, 2001).

In El-Tigi and Branch's second phase, the emphasis is on *specific practical attributes* presented as follows:

1. *Templates* can be provided for the formation of mental structures to support learners in attempting exercises.
2. *Learning content should be tested and debugged* before being uploaded online. Evaluation and debugging help to assess the usability of the content and instructional methods, as well as the accuracy and currency of the subject matter.
3. Educational websites should provide features for *users to evaluate* the website, since feedback from users is vital for improving usability.
4. A WBL application should recognise group ownership and, more importantly, provide *protection from liability*. This can be achieved through avoidance of plagiarism, acknowledgement of others' work and inclusion of suitable disclaimers.

5. The sites need to be *modifiable and adaptable*, so that positive changes can be incorporated to improve quality and efficiency (El-Tigi & Branch, 1997).

2.4.7 WBL and its underlying learning theory

In Section 2.4.5, the learning theories underlying CAI were mentioned. This section relates WBL to its underlying learning paradigm. Learner-controlled WBL is often an implementation of constructivism. Searching on the networked structure of the Web lends itself to the kind of learning where learners independently seek out their own knowledge and interpretations. Jonassen (1999) explains the design principles that can be used to develop what is referred to as a *constructivist learning environment* (CLE), which is a real-world environment in a relevant context. A CLE provides tools and environments that support learners in the interpretation of multiple perspectives on an issue. It enables learners to undertake cognitive and creative activities and to have effective interaction with the WBL. Alessi and Trollip (2001) point out factors that characterise the design of WBL applications: navigation, hypertext links, orientation, hypermedia format, browsers, speed, multimedia components, visual layout, structure and international factors. These features support flexibility and lend themselves to independent research and the self-instruction approach of constructivism.

2.4.8 Information architecture in Web-based learning

Web-based learning systems usually present information in non-linear formats with a structure of nodes (Dillon & Zhu, 1997; Dix *et al*., 2004; Starr, 1997). Such information is in a hyperlinked structure where users scroll and click for information. There is a need for balance between scrolling and clicking to access required information (Dix *et al*., 2004). There are also concerns about low access speeds that limit the use of WBL applications in certain localities and in particular conditions, such as multiple graphics (Starr, 1997; Alessi & Trollip, 2001). This is likely to affect the learning pace and may contradict the view that WBL is a tool that brings the classroom closer to the learners. In this context, therefore, the emerging challenges in WBL systems need solutions. Lohr (2000) proposes three key principles of presentation and perception to address learners' cognisance of information and to support learning gain from WBL applications. These are:

- Figure/ground,
- Hierarchical, and
- Gestalt.

2.4.8.1 Figure/ground

This principle advises designers to "make the most important information distinct" (Lohr, 2000:48). Key information should be visually distinctive so that it stands out. To achieve this, Dix *et al*. (2004) recommend use of correct contrast styles. Furthermore, the background of a website should not be visually noisy with multiple colours and features.

2.4.8.2 Hierarchical

This principle presents the need to "establish a visual order of importance for users" (Lohr, 2000:48). In this regard, Mullet and Sano (1995) suggest that the information should be visualised in such a way that learners have a systematic and well-structured experience of the intended learning.

2.4.8.3 Gestalt

The principle emphasises the broader picture of the information (Lohr, 2000). This requires the information to be organised "so that it is perceived as part of a larger harmonious whole" (Lohr, 2000:50). Such design techniques demonstrate the relationships between distinct information items.

In an early approach, still relevant today, Starr (1997) highlights the key feature of websites, namely *hypertext* that enables user control of information, as they focus on what they really need in a non-linear manner. Graphical browsers are used for *delivering multimedia* on the web. In situations with bandwidth constraints, information can be delivered by streaming formats or learners can have the option of accessing limited content, which load faster. Finally, Starr stresses that the learners need *truly interactive* information exchange to improve on the quality of learning.

Web radio and Skype are recent developments that can be used to support learning. Web radio and Web camera (Webcam) can help learners to access more information through collaboration and by having online discussions with other learners (Hart, 2003). Skype is a facility that enables users to make use of free audio and video calls and instant messaging over the Internet (Skype website, 2009).

In this section, the discussion was centred on the design of Web-based learning and the information that is provided on a website. The next section discusses learning management software.

2.4.9 Learning management systems

A learning management system (LMS) is a form of application software for presenting, supporting, recording progress of, and managing e-learning. It incorporates other applications and utilities – independent or built-in – which play important roles. It is frequently through an LMS that users are provided with usable interfaces to the actual instructional application (Gayeski & Brown, 2004). LMSs manage the delivery of e-learning courses, and enable instructors to publish and upload course content. LMSs can simultaneously track and record the performance of all the learners (Zarrabian, 2003).

Some of the academic LMSs available in the market include WebCT, Blackboard and e-College (Itmazi & Megías, 2005). LMS development should be based on technologies that are appropriate for the content, context and instructional methods they will support (Vrasidas & Glass, 2002). Vrasidas (2004) warns that any advancement in technology should primarily address the interests of the e-learning stakeholders. The technology should seize the potential of any tool that may enhance the human interaction (Barton, 2004; Reigeluth & Carr-Chellman, 2009). The authoring facilities within LMSs provide interfaces between educator and the programming language that implement the uploading of academic content, that populate the databases, and that manage the search facilities (Zarrabian, 2003).

This section addressed web-based learning and the associated design issues. The next section relates to virtual learning environments and the use of multimedia applications in e-learning.

2.4.10 Virtual learning environments

Virtual learning environments (VLEs) are another popular tool. VLEs enable the learners and their instructors to have online interaction sessions of different kinds, often in a simulated 'class' situation (JISC, 2000). There are three areas that are notably important to the implementation of VLEs, although they are equally relevant to certain other learning environments (Catherall, 2005):

- *Technical skills* are needed to install, configure and maintain the VLE software and hardware, so as to integrate the system with modules running in other institutions of learning.
- *User and course records management* are important for the maintenance roles carried by support staff in conjunction with the academic and technical staff.
- *Training and user support* may be spread between support staff and professional staff. The support functions include user-awareness, staff and learner training, and production of support material.

2.4.11 Multimedia e-learning applications

Multimedia environments are not an e-learning methodology of their own, but are incorporated in the forms of e-learning already considered, for example, CAI and WBL. Nevertheless, a separate section is devoted to multimedia, in order to highlight its particular features and requirements. The multimedia/hypermedia technologies require seamless integration of text, sound, video and images within an application (Cybulski & Linden 1999; England & Finney, 1999). Hypermedia programs are characterised by databases of information, which are navigated by many different means, but particularly by hyperlinks.

A further essential feature of hypermedia is the use of multiple media for presentation of content, such as text, graphics, video and audio (Alessi & Trollip, 2001). Due to the paradigm of object-oriented programming (OOP), increased use of multimedia has occurred in applications development, including extensive use in the development of e-learning. OOP enables reuse of self-contained entities in different applications (Downes, 2005), and reuse occurs in the development of learning content. It can be beneficial to take traditional lessons prepared and presented by good teachers and transform them into high quality multimedia e-learning applications. A good human instructor has the ability to speak and explain using illustrations and slides, to write on a board, and to use animations to engage learners' attention. If such sessions are converted to electronic environments, the success of the lessons will depend on the simplicity of the navigation mechanisms and the usability of the multimedia features (Fiore & Bochicchio, 2002). It should however, also capitalise on the interactivity offered in computing and avoid merely using the screen to present what was formerly in print or on a board. In addition, multimedia e-learning applications should recognise the existence of varying knowledge needs from different learners. Presentation of material in multiple formats can meet the learning preferences of these different learners. However, although appealing sounds and aesthetic pictures and graphics may make a multimedia lesson engaging and attractive, they do not necessarily enhance learning (Dix *et al*., 2004; Redmond-Pyle & Moore, 1995). Such features need to be relevant to the content.

The discussion following considers both online and the offline multimedia systems.

2.4.11.1 Online-based e-learning applications

Online learning is mediated by real-time network technologies (Lim, 2002), accessing distant resources through the Internet or network (England & Finney, 1999). Most multimedia online applications have content in different data formats, including graphical, audio and textual modes.

Online-based e-learning does not necessarily change the way learners acquire knowledge and skills (Engvig, 2006). Traditionally, educators would control the amount of the content that reaches the learners. This has changed due to the independent availability of web-based information to learners, even without instructors. The amount and sequence of content delivered to learners might be mediated by the program (system control) or learners might be empowered by user control to independently select content.

2.4.11.2 Offline-based e-learning applications

Offline e-learning applications are self-contained in that they do not interact with the external environment, other than with learners (England & Finney, 1999). In offline-based learning, it is easier to prepare responses offline and automatically synchronise at the next online connection (Feldstein, 2005). It is cost effective in remote areas, where projectors can be used for multiple learners in the same location to access content from a single computer (Mackintosh, 2005).

Even though offline-based applications can bridge the digital divide between, for example, rural and urban schools, the main challenge remains updating the instructional content presented on fixed media such as CD-ROMs. Alessi and Trollip (2001) point out that most commercial hypermedia programs do not permit modification of their content, nor can users provide input to such pages created by other authors. There should be means of calculating the cost and efficiency when updates are required, especially at tertiary levels (Zemskey & Massy, 2005).

The discussion in this section addressed various forms of e-learning and e-learning software, which are continuously evolving to satisfy emerging needs and changing technologies.

2.5 Further aspects of e-learning

The use of e-learning has been increasingly promoted in recent years due to lower pricing for hardware, data storage, software and related technologies (Bush, Walker & Sorenesen, 2011). Further factors related to the support, enhancement, and production of e-learning are addressed in this section and in Section 2.6. Some aspects have overlaps with previous material in this chapter.

2.5.1 Components of e-learning

The assumptions made in designing e-learning for a particular purpose determine the characteristics of its content (Good, 2001). The technology and the learners are of equal importance and attention should be paid to the type of learner and the nature of the learning material, for example, the components of e-learning for academic use may differ from those of e-training for business purposes. Tucker, Pigou and Zaugg (2002) identify the three major components of e-learning as technology, learners and content.

2.5.1.1 Technology

Some technologies can develop e-learning that is simultaneously available in different formats, such as collaborative, synchronous and online (Tucker *et al*., 2002). The availability of e-learning is a function of the technical infrastructure (Borotis & Poulymenakou, 2004). Tucker *et al*. identify the roles of technology in e-learning as follows:

- Creating the content of an e-learning application.
- Capturing the content by technological equipment, for example, camera, or text input via a keyboard and transferring it to the learning environment, usually a computer.
- Editing and encoding the captured content to enhance them.
- Delivering/receiving of content on high demand, for example, the use of streaming server for videos.
- Testing and tracking the content.

The rapid growth in the use of mobile telephony has led to another technological means of access to learning and informational content, termed m-learning (Traxler, 2007). Moreover, there is the need to develop wireless application protocol (WAP) pages and mechanisms should also be applied to address offline availability of such pages to learners.

2.5.1.2 Learners

Learning is about experience and knowledge brought to the learning environment for learners' benefit (Fuller, Norby, Pearce & Strand, 2000). Learners require a supportive setup that facilitates their use of e-learning, especially in a new environment (Borotis and Poulymenakou, 2004). To enhance the learning process, referring especially to workplace e-training, Tucker *et al*. (2002) suggest a variety of contexts where e-learning can be applied:

- Short content addressing a specific need.
- Just-in-time learning where learners require current knowledge.
- Recurrency and in-service training, in a form that keeps regular records of learners' progress and establishes completion rates.
- Presentations on an intranet for authorised learners.
- Certification and compliance of experts to support them in the process of remaining accredited in their professions.

Over and above the situations listed above which, as stated, relate mainly to workplace and professional e-learning, conventional education is frequently supplemented by e-learning methodologies.

2.5.1.3 Content

E-learning content is seamlessly available in websites and collaboration sites (Good, 2001). This requires proper management of the content, which is frequently done by a suitable LMS. The presentation of content in different formats should be facilitated. LMSs can shield educators and facilitators from the complexity of uploading content in different formats (Zarrabian, 2003). With regard to the format presented to learners, varying fonts and text formatting techniques can be used to stress important features (Dix *et al*., 2004). Audio, slides, video, handouts and tests are also important aspects of the content. Technologies that promote compatibility of content, interactivity, reusability and interoperability should be used in the LMSes (Borotis & Poulymenakou, 2004; Dix *et al*., 2004).

2.5.2 Characteristics of e-learning applications

Zarrabian (2003) proposes five main factors that should characterise e-learning applications:

- Maintainability,
- Compatibility,
- Usability,
- Modularity, and
- Accessibility.

2.5.2.1 Maintainability

Maintainability is a desirable characteristic of the design and installation. It should be possible for routine maintenance tasks of an e-learning application to be done with ease. Furthermore, ease of administration provides independence from vendors (Zarrabian, 2003). As far as possible, systems should separate content from structure. Song (2004) advocates that learning activities should be maintainable by educators, not only by developers. This reduces accidental deletion of important features during content updates.

2.5.2.2 Compatibility

An e-learning system should be compatible with others in general use. Zarrabian (2003) calls for applications that conform to widely recognised standards. This is possible through interoperability, which is the seamless movement and use of content between different applications (Schach, 2000). Zarrabian (2003) presents various guidelines for selecting a compatible LMS:

- Content should be transferable from one LMS to another.
- It should be possible to use the created content within various learning management systems.
- The authoring package in use should be compatible with a newly-acquired learning content management system (LCMS).
- There should be ease of learning for stakeholders who must use the software to create courses rapidly.

2.5.2.3 Usability

Usability addresses users' satisfaction with an application (ISO 9241, 1998; Preece *et al*., 2007). Satisfaction includes the ease of learning on first exposure, and ease of use thereafter without hesitation (Dix *et al*., 2004; Rubin & Chrisnell, 2008). Learners should be confident that an e-learning system is easy to use (Zarrabian, 2003; Reigeluth, 2011). They need to grasp the learning goals, the strategies, and the methods for extending their base of knowledge and attaining understanding (Fuller *et al*., 2000). The learners also need to feel that their learning environment offers them improved opportunities for learning and for personal creation of knowledge (Reigeluth, 2011; Squires & Preece, 1999). E-learning applications should therefore be pedagogically appropriate, regardless of how aesthetically attractive they may be to users (Ardito *et al*., 2004). The technology should support successful teaching strategies; help facilities should be readily available and easily understandable.

The usability of e-learning applications is addressed in Section 3.3 in Chapter 3 which is dedicated to usability evaluation.

2.5.2.4 Modularity

Modularity enables a large system to be built of small independent parts. To enhance maintainability, e-learning systems should be composed of small interchangeable objects known as modules. Modules may be in the form of small pieces of instructional content (Zarrabian, 2003) that are reusable for effective utilisation of resources.

2.5.2.5 Accessibility

Authorised learners should be able to access e-learning applications regardless of obstacles and physical distance (Zarrabian, 2003). Applications should be hardware- and platform-independent to ease accessibility. Good (2001) suggests that supplementing the educational content with e-mail and/or conferencing facilities can further enhance accessibility.

2.6 Issues associated with the production of e-learning applications

There is a need for a sustainable support base for e-learning applications. The learning experience should be targeted, paying attention both to human facilitators and technological aspects (Savidis, Grammenos & Stephanidis, 2007). There are instances when learners need support from educators to understand learning material (Reigeluth, 2011) and such support should be readily available. Other factors that affect the production of e-learning applications include the choice of tools to apply and the technological skills required to develop the applications. These are discussed in the subsections that follow.

2.6.1 Design and development of e-learning applications

The design of e-learning systems influences how the learners and instructors may interact with a system. There should be flexible trade-offs between cutting cost and maintaining quality (Zemskey & Massy, 2005). Flexibility is influenced by factors such as the needs of the stakeholders (learners, educators and supervisors), the available facilities and the technology to deploy. Key aspects of design and development include the following (Srinivas, 2006):

2.6.1.1 Target identification

Design should be driven by identification of the eventual end-users, which helps in scoping the activities. For example, in situations of CD-based tutorials, end-users ideally require content updates that can be availed in CD form.

2.6.1.2 Needs assessment

There should be assessment of the needs of the target learners as part of the development of the learning objectives and goals (Liu, 2001; Srinivas, 2006). The assessments can be done in various ways, one effective method being the use of well-structured questionnaires to capture learners' opinions.

2.6.1.3 Packaging information

Information can be packaged based on the varying needs of the learners (Srinivas, 2006). For instance, new learners have different needs from those of frequent users. Information packaging should be well organised and free of complexities that could make it difficult for certain learners to understand (Pisik, 2004).

2.6.1.4 Marketing

Marketing should particularly target the educators since they play important roles in selecting products. In some cases, learners may be offered direct access to trial versions.

2.6.1.5 Delivery modalities

Suitable infrastructure should be developed for the delivery of e-learning. It is appropriate for certain e-learning applications to be online while others are better presented offline, for example, on CD-ROMs. The frequency of access and location of the users will determine the appropriate formats for delivery.

2.6.1.6 Support systems

In cases of blended learning, where learners use technology in a class or laboratory situation, support systems for addressing queries and discussing learners' comments should be available during the sessions and afterwards for necessary follow-up (Srinivas, 2006). The instructions from the system should be consistent and easy to understand (Pisik, 2004). Feedback should help learners to obtain the appropriate factual information (Luterbach, 2005; Watson & Doolittle, 2009).

2.6.1.7 Monitoring and evaluation

Learners' use of e-learning applications should be monitored (Srinivas, 2006). The information so gained should be analysed to assess the quality of the e-learning applications. The tools and instruments used for evaluation should be able to evaluate a broad range of aspects, such as the content, instructional design, operation and format of the system (Reiser, Alfano, Brooks, Pethtel, Brogan & Vann, 2005). The evaluation criteria used in this study aim to address, among others, most of the aspects.

2.6.1.8 Currency of content

It is important that content of e-learning applications is updated and kept current. This is easy for product delivered via WWW, but for stand-alone applications, such as those delivered on CDs, it involves re-issuing. However, Liu (2001) suggests that flexibility for future updating of the content should be factored into the design. This will ensure that the system is able to support the most recent subject matter and can be viewed as a preferred medium of acquiring required knowledge.

The next section discusses the use of metadata in e-learning.

2.6.2 Metadata in e-learning

Metadata is data about data. It is structured to facilitate ease of access, management and use of an information resource (Berendsen, Hamerlinck, & Wayne, 2000; Guenther & Radebaugh, 2004; Milstead & Feldman, 1999). Metadata is constructed information that results from human invention, for example, the use of longitude and latitude to describe the earth (Coyle, 2004). Metadata is essential for managing multimedia resources such as images, films and other content (Simon, 2002). E-learning systems require metadata that is focused on particular target groups of learners.

Metadata uses simple keywords to organise information and artefacts (Vuorikari, Sillaots, Panzavolta, Koper, Schoolnet, Treves & Netherland, 2009). Artefacts can be described as reusable multimedia components and processes (Cybulski & Linden, 1999). The keywords (known as tags) can be used to represent and organise objects such as pictures, bookmarks of web addresses and Webfeeds. Tags can be used to manage and classify user's own digital knowledge artefacts, and to link to users who have similar interest and goals (Vuorikari *et al*., 2009). The quality of the tagging of artefacts is an important issue in the presentation of e-learning systems (Liu, 2001).

The next section addresses technologies that enable work teams to use the various tools.

2.6.3 Work team tools in e-learning

Work team tools are software applications that enable groups of users to access documents on shared work interfaces through synchronous or asynchronous modes (Dix *et al*., 2004). This enables a team to update the same document from different locations. The set of tools should include audio conferencing and text messaging applications. To improve the efficiency of work team tools, they should also contain decision-support functions for brainstorming and voting (Gayeski & Brown, 2004). Such facilities eliminate the time-lag associated with e-mail exchanges (Bonk, 2002), since they enable communication of new knowledge in good time and fast decision-making. This enables instructors to provide notes for learners by marking on an electronic copy.

The next section addresses the skills required to develop e-learning applications.

2.6.4 Skills for developing content of e-learning applications

Instructional design theories and models should have prescriptions and descriptions for curricula, lessons and learning tasks (Kang & Byun, 2001). Developers of e-learning applications should understand the varying trends and requirements, such as the difference between distance learning and situations where e-learning applications are blended with classroom learning. Howard, Schenk and Discenza (2006) emphasise that it is essential for developers to have an understanding of learners and their needs, as well as the modular development of learning content. Updates should be conducted regularly as part of routine maintenance. There should be support for the *anytime and anywhere* classroom, and where appropriate, an environment should offer a classroom atmosphere to the learners (Waterhouse, 2005).

Good language, grammar, sound pedagogical and cultural practices are important in content development (McBrien, 2005). The target languages of use, for example English or French, should be clearly stated in a system. It may be necessary to provide appropriate external glossaries, such as industry-standard terminology. Where learners and educators are familiar with certain platforms, consistency to these platforms is an advantage. The use of gender-specific roles, culture-specific, geographical and historical references should be avoided or, if used, it should be with discernment.

Usability evaluation of e-learning applications, their platforms and the component modules is an important aspect of e-learning. Although relevant to this section on issues surrounding e-learning, evaluation is not discussed here. It is so fundamental to the present study that the whole of Chapter 4 is devoted to it.

2.6.5 Skills for managing e-learning environments

Managing a learning environment requires a clear understanding of the type of learners as well as the form of the learning objectives. According to Hezemans and Ritzen (2002), learning environments occur in a variety of completely different forms. They may be task-based, problem-based, or situation-based.

The aim of task-based environments is for learners to conduct a task(s) that contributes towards a set goal. The approach is focused and operational, so that the results obtained by the users/learners in the set context should help them to achieve the intended purpose. In a problem-based learning environment, the aim is for learners to attain an intended objective by solving actual problems. It takes a tactical approach by challenging the users to reach a solution based on a given scenario. Just as for task-based, its methods and solutions must meet the set criteria. Thirdly, situation-based environments involve achieving the intended objectives through improving an existing situation. Being a strategic approach, it should be innovative. However, the innovations in the methods and result should conform to the set criteria (Hezemans & Ritzen, 2002).

In managing dynamic and ongoing learning environments, it is particularly demanding to manage virtual learning environments (VLEs), which were introduced in Section 2.4.10. VLEs offer content sharing, links to existing educational modules, assessment tools, virtual classroom situations, discussion boards, and certain LMS facilities. These complex environments present their own unique sets of requirements. Aspects of project management and project planning, such as contingency plans, should be applied. Experiences of learners with e-learning environments should be studied to help managers determine the required levels of assistance (Watkins, 2005).

The next section discusses the different challenges that face e-learning and calls for proper management of human capital and technology.

2.7 Major challenges of e-learning

E-learning requires newer, cost-effective solutions to meet the increasing demand. There are various challenges that affect people (learners and instructors), technology, and the e-learning content. The main ones are discussed in the following subsections.

2.7.1 Challenges for learners

The exercises provided in electronic learning resources should be closely related to the content presented in the teaching and learning segment and the scope should be clearly defined (Kreber, 2009). Certain forms of e-learning, such as online learning, may result in individual learners feeling isolated as they attempt to acquire knowledge within a changed environment (Kelly, 2004).

Learning guidance may be required from educators to support learners in achieving success. Such guidance may be built into the courseware as a vital component of learning architecture, with knowledge management and performance being equally important.

2.7.2 Challenges for online instructors and developers

It is desirable, though not always possible, for e-learning to occur alongside certain human elements, such as some face-to-face interaction. In certain cases, educators may find it difficult to interact regularly online with individual learners (Kearsley & Blomeyer, 2004). Reasons for this include problems in being readily available, fear of technology, and poor infrastructure. However, where these issues can be overcome, synchronous learning can provide meaningful one-on-one interaction between educators and individual learners (Fuller *et al*., 2000). Online educators can communicate electronically with learners by means of e-mail, chats, podcast and even social networks. The more usual roles of educators however include involvement in designing and managing the courseware, and evaluation of learners (Vrasidas, 2004).

The task of actually designing courseware includes:

- developing the curriculum and related material,
- deciding on the learners' activities, and
- selecting suitable learning strategies and media for the learners to achieve the learning outcomes (Vrasidas, 2004).

A further challenge involves suggesting to application developers that they should make changes based on information from users (Gulliksen, Boivie & Goransson, 2006) and this approach is also relevant to learning systems. This calls for directions and feedback that should be provided on an ongoing basis. Additionally, the technological tools used in e-learning require the instructors to be skilled in instructional design, so as to optimally present the learning content. Vrasidas (2004) indicates that instructors may also be expected to:

- monitor learners' enrolments and progress records,
- require timely submission of assignments,
- administer course information, and
- set up the rules and procedures for learning-related activities.

All learners on a course should have opportunities to contribute to discussions. Synchronous tutorials can support this, along with management of learners' discussions and individualised attention to their queries. Internal usability evaluation of a system prior to going operational can help to determine whether it is suitable for the intended target group. Usability testing should commence as early as possible in the development cycle (Kuniavsky, 2003). In the next section, the technological challenges in e-learning are discussed.

2.7.3 Technological challenges

Many existing technologies do not effectively implement current e-learning paradigms (see Section 2.2.4), such as collaborative and constructivist learning models (Gayeski & Brown, 2004). This may be due to the unavailability of supportive technological infrastructure for educators, even in cases where they are skilled in designing and conducting online classes (Vrasidas, 2004). Rosenberg (2001) suggests that technology can lead to re-invention of some teaching and training aspects and re-engineering of traditional processes.

The discussion that follows, addresses challenges that arise mainly due to the Internet and related security issues.

2.7.4 Challenges related to Internet access

E-learning content is implemented using different data formats such as graphics, textual and streaming videos. Most courseware content, except textual data, requires high-bandwidth, which poses challenges for learners in remote locations (Catherall, 2005). The cost of Internet access in some developing countries is very high. These challenges necessitate innovative strategies to provide the same learning content to different economic sectors of society. However, this should not compromise the quality and delivery of applications. Wainer, Neil, Green, Mislevy, Steinberg and Thissen (2002) identify challenges related to the use of Internet in e-learning as follows.

- Time constraints
- Cheating and inappropriate test behaviours
- Omission of questions and associated scoring.

2.7.4.1 Time constraints

This challenge requires flexibility in the period allocated to complete an online test. There may be different connectivity speeds in different examination venues. There may also be delays in loading screen displays, a problem that is exacerbated with graphical content.

2.7.4.2 Cheating and inappropriate test behaviours

From the patterns in which learners present their answers to test or examination questions, it may be possible to detect if cheating occurred. If a learner correctly answers a series of questions followed by a series of wrong answers, it may indicate prior access to the first few questions.

2.7.4.3 Omission of questions and associated scoring

Learners may decide not to attempt certain questions. This poses a challenge when scoring those questions. Negative marking should not be used, because opting not to attempt a question, does not necessarily mean that the learner was wrong. The marking scheme should be well planned.

2.7.5 Security issues for e-learning applications

Security of e-learning applications can lead to vulnerability and unavailability of the resources. Various issues are discussed by Catherall (2005):

2.7.5.1 Password

Learners have a tendency not to reset the default passwords, but to continue using them. There should be mandatory mechanisms that force users to change their password at the next log-on, but such mechanisms are seldom available in e-learning systems.

2.7.5.2 Guessing web addresses

Some learners with wrong motives may take an informed guess at a web address that is intended to be inaccessible. For example, a learner might take a guess such as *solutions.html* for the URL of solutions to an assignment.

2.7.5.3 Ambiguous user identity

In the event of a learner not logging-off from a session, another learner can proceed with the work. This makes it easy for such users to masquerade as the authentic user.

2.7.5.4 Non-repudiation

When a learner uploads a project or assignment, some e-learning sites have no means of authentication. It cannot be determined if the person submitting, is the one who did the work. Further complications occur in cases where there is no feedback to inform learners if the submission attempt failed or if a system crash occurred.

2.7.5.5 System vulnerability

Novice users may unknowingly tamper with configurations of the system that they are using. This may become a security threat that raises the system's vulnerability to intrusion.

Some of the above challenges may be overcome by use of *computer adaptive tests* (CAT), which adapt to the abilities of the learners being tested (Thissen & Mislevy, 2000), based on their performance in the previous questions. Furthermore, sound procedures should be used to identify learners who are sitting for the examinations (Davey & Nering, 2002). The examinations should be protected from pre-exposure during development.

2.7.6 Other limitations of e-learning applications and tools

Although e-learning technologies have advanced, some applications support only one-way delivery of information (Gayeski & Brown, 2004). Gayeski and Brown give examples of complex collaboration and teamwork, explaining that many e-learning applications do not support these features.

Many organisations have welcomed e-learning and have adjusted their working frameworks to implement e-training. However, according to Pisik (2004), the use of e-learning has been hampered by inappropriate evaluation tools and methods for evaluating the applications. Some of the standard software evaluation tools and instruments do not adequately address important learning needs. This is discussed in Chapter 3 which is devoted to evaluation of e-learning. The next section discusses how e-learning is a delivery mechanism.

2.8 E-learning as a delivery mechanism

E-learning as a mechanism for delivery of learning incorporates different styles to ensure that the intended objectives are achieved. This section discusses blended learning and distance learning as some of the styles that are used.

2.8.1 Blended learning

Blended learning refers to situations where learners are exposed to class-based teaching as well as e-learning. A specific connotation is that blended learning incorporates some of the best practices of the conventional classroom into e-learning. The extent of blending is normally influenced by the intended learning objectives. At the time when e-learning emerged, there was a sense that the promises of online media were yet to be achieved (Macdonald, 2006). An aim of blended learning was to resolve some instructor-related challenges (Catherall, 2005):

- Through blended learning, educators were assured that e-learning applications were merely providing additional teaching resources, and not replacing traditional teaching and learning.
- Use of e-learning systems often relies significantly on the actual educators for successful implementation.
- Educators should be part of development teams.
- Regular refresher workshops should be held to strengthen the educators' IT skills.

In addition, blended learning has varying requirements that depend on learners' ages and special needs, contributing to the development and implementation of e-learning applications that are guided by sensitivity to the stages of learning (Gray, 2006).

There are pitfalls in blended learning that should be avoided. Brodsky (2003): identifies some of these and suggests preventative measures that can contribute to better quality.

2.8.1.1 Failure to think ahead

Where e-learning is the primary mode of delivery, other methodologies for optimising learning and performance may receive inadequate attention. A significant number of e-learning strategies are characterised by the absence of classroom components (Lim, 2002). This can be prevented through proactive blending (Brodsky, 2003) which acknowledges the strengths and limitations of e-learning at conception and design stages. Moreover, blended learning should include the strengths of online learning to compensate for weaknesses of classroom learning (Lim, 2002). This requires thinking ahead and development of viable strategies.

2.8.1.3 Lack of clear learning objectives

The learning objectives should be clear and matched to the methodologies. Educators who promote the use of e-learning may underestimate the impact of poorly-defined learning outcomes and vague time-frames. Performance analysis should be conducted on these aspects, ensuring that the learning objectives are clear and identifying areas where skill and knowledge gaps should be addressed.

2.8.1.4 Lack of right blend of expert resources:

Failure to obtain and integrate the right blend of expert resources can impede learning. Development teams should be knowledgeable not only in software development skills, but also in training techniques and know how to combine them. They should be conversant in the subject matter and, where necessary, should seek input from subject-matter experts. Such quality assurance measures should also involve learners, instructors and other stakeholders.

2.8.1.5 Blended implementation approach failures

There should be effective execution of blended implementation approaches. The implementation strategies should have cohesive performance action plans, indicating the functionality of the contact elements and the e-learning. The plans should also indicate the methodologies to be used throughout the teaching and learning processes and in assessment.

2.8.2 Distance learning

Pure distance learning is learning conducted without conventional contact teaching. It originally occurred via conventional mail, radio and television (Alessi & Trollip, 2001), but these forms are now supplemented and strengthened by electronic media, that is, web-based learning and e-learning as described in this chapter.

To support online education and training via the Internet and World Wide Web, the LMS (see Section 2.4.9) becomes a dominant technology for assisting learners in accessing appropriate content (Downes, 2005). LMSs also play important roles by providing facilities for learners to upload their assignments and projects and monitoring their progress. By contrast, stand-alone e-learning systems, such as those delivered via CDs, are an important part of independent learning, since progress is not recorded.

2.9 Instructional design in e-learning

Instructional design (ID) is the process of using a development framework to systematically plan the events for guided learning (El-Tigi & Branch, 1997; Muilenburg & Berge, 2005; Smith & Ragan, 2005). The systematic design of instructional materials was initially applied in the design and development of printed textual materials, but this section relates to more recent ID in the context of e-learning. The planning should first take cognisance of the computer literacy levels of the intended learners (McDonald, 2010; Starr, 1997). Learning cannot be approached as an ordinary task that has a stated problem needing solutions (Squires, 1999). The following five principles identified by Merrill (2002) are helpful in the instructional design of educational software:

- Demonstration principle - the learning process is illustrated by presenting a demonstration.
- Application principle - learning is enhanced when learners apply the new knowledge acquired.
- Task-centred principle - learning is well supported when learners use a task-centred instructional strategy in the learning process.
- Activation principle - learning is encouraged when learners use their appropriate prior knowledge or experience as a foundation.
- The integration principle – learning is supported when learners consolidate their new knowledge in their daily lives.

A design process should commence by initially defining a narrow list of system features to get a clear picture of its capability (Pullin, 2009). It is also important that usability aspects are considered right from the early phases of the development cycle.

In an early learner-centred approach for designing instructional resources on the WWW, Starr (1997) indicates that successful instructional design should begin with learner analysis. The ID should incorporate suitable external resources that can be used for:

- learner analysis,
- external resources,
- updating and expansion, and
- evaluation.

These points are elaborated below.

Learner analysis: This is necessary to generate suitable designs that incorporate good interaction capabilities, appropriate learner control, and the provision of feedback to learners after their activities. Different categories of skills may require varying interaction modes and levels of user control. This in turn may impact on the feedback given, where the term ‘feedback’ can relate both to responses to learners’ activities and user evaluation facilities.

External resources: Where possible, existing e-learning applications available on the World Wide Web (WWW) can be used to avoid unnecessary duplication (Starr, 1997). Further expansion, along with proper evaluation, of such systems should be considered to accommodate specific user needs while ensuring that the system remains fit for its primary purpose (McDonald, 2010; Starr, 1997). However, stand-alone applications such as multimedia resources on CDs can also serve to supplement teaching and learning, as is done with the target system in the present study.

Updating and expansion: Properly planned instructional design ensures updates and expansion to WBL for it to retain its currency. Starr (1997) advises that elements on web pages should be grouped according to topics, facilitating the use of particular content and supporting learnability of the website. Hyperlinks provide accessibility to grouped information. Such defined structures also expedite updating of the site.

Evaluation: Ideally, there should be feedback mechanisms within a system for user evaluation that accepts users' input and captures the problems they experience with interaction and control facilities. The feedback formats should allow users to give open-ended suggestions about a system.

2.10 Summary and conclusion

The chapter overviewed e-learning and learning theories. From the discussions on e-learning in this chapter and the review of learning theories in Section 2.2, it is evident that different forms of e-learning are based on different learning theories and that the various e-learning methodologies induce different kinds of learning among users. The theories of behaviourism, cognitivism, constructivism, and hybrids between them are underlying paradigms on which e-learning systems and strategies that drive them, are developed.

E-learning was discussed in Section 2.3 with a view to understanding the features of e-learning systems. The discussion in Section 2.4 focused on traditional CAI, e-learning tutorials, drills, simulations, WBL, and the learning management systems that are used to facilitate e-learning. The discussion showed how CD-based tutorials are different from those of other forms of e-learning because of their offline nature. Section 2.5 discussed the components of e-learning, namely learners, technology and the content. Based on those components, Section 2.6 covered the issues that are associated with e-learning applications.

In Section 2.7, the challenges of e-learning were discussed, touching on the learners, educators and technology, and the need to address them to sustain learning. Some of the challenges can affect the mechanisms for delivering learning as discussed in Section 2.8. In this regard, educators and subject-matter experts are vital role players, along with software developers in guiding the design of environments that are based on appropriate learning theories and that present the learning content accurately. These challenges include distance learning and blended learning in which electronic learning mechanisms can be a valuable source of learning material and supplementary support. The chapter culminated by stressing the importance of sound instructional design in the development of e-learning in Section 2.9.

A major contribution of this chapter is that its subject matter is applied in Chapter 4 in the process of synthesising criteria for evaluating interactive e-learning tutorials. The criteria are used in the two empirical evaluation studies conducted in this research and described in Chapter 7.

The next chapter (Chapter 3) builds on e-learning by covering usability evaluation of e-learning applications. It addresses interaction design, usability, and usability evaluation methods and criteria. These aspects also contribute to the synthesis in Chapter 4 of criteria for evaluating interactive e-learning tutorials.

Chapter 3: Usability evaluation of e-learning applications

3.1 Introduction

This chapter focuses on some human-computer interaction (HCI) aspects of e-learning products. It discusses the concepts of usability and usability evaluation within the context of interaction design and instructional design. Usability addresses the level of effectiveness, efficiency and satisfaction and how these attributes assist a user to achieve specified goals when using a system in a given environment (ISO 9241-11, 1998). Usability evaluation should address a system's effectiveness, ease of use and whether it satisfies users' goals (Davis & Shipman, 2011; Rosson & Carroll, 2002). Evaluation should review the use of the interaction design and user-centred design in the system (Preece *et al*., 2007). Usability can be measured empirically or analytically, and a study of the available usability evaluation techniques and approaches will help the researcher to determine which methods and tools to apply. The empirical approach aims at identifying the real usability problems encountered by users while analytical ones investigate, among other things, how the problems affect the use of the system (Hollingsed & Novick, 2007).

It is also important to develop criteria for usability evaluation of educational applications in general, and to decide on criteria for this study in particular. In evaluating e-learning applications, pedagogical aspects and the attainment of learning outcomes can be included in the evaluation criteria (Carter, 2007). This relates to elements of the application that support or impede learning. As was the case with Chapter 2, the material in this chapter thus provides criteria appropriate for evaluating interactive e-learning tutorials and contributes to answering Research Question 1. It also provides information on different usability evaluation methods that are relevant to the empirical studies described in Chapter 7. Chapter 3 therefore also contributes towards answering Research Question 2.

Section 3.2 introduces interaction design and how it relates to the development of an interactive system. Section 3.3 discusses usability and the usability of e-learning, based on learner-centred design. It also presents usability principles and evaluation. Usability evaluation methods are considered in Section 3.4, including the ones applied in this study. Some aspects of empirical evaluations are outlined in Section 3.5. Section 3.6 introduces classic criteria for usability evaluation as a background to Chapter 4, which is dedicated to the actual evaluation criteria used in this study. Chapter 3 concludes in Section 3.7.

3.2 Interaction design

3.2.1 What is interaction design?

Interaction design is a planning approach that addresses the users of a system, and their activities, and how these users would relate with the system to satisfy their needs (Preece *et al*., 2007). 'Interaction design' is an umbrella term, with a different scope from the term HCI. It relates to aspects such as user interface design, user-centred design, product design, web design, interactive system design, and also to the newer concept of user experience. It is "concerned with the theory, research, and practice of designing user experiences for all manner of technologies, systems and products" (Preece *et al*., 2007:10), whereas HCI focuses on design, evaluation and implementation of interactive computing systems. Korhonen, Arrasvuori and Kaisa (2010) confirm that a design should consider user experience aspects, which relate to users' emotions when interacting with systems. Moreover, Khan (2002) suggests that a system that is to be used worldwide should take account of cross-cultural communication matters, so as to be relevant to different learners.

The intention of interaction design is to achieve efficient systems that support high productivity among the users. As suggested by Preece *et al*. (2007), the design should include a challenging and motivating system interface that is easy to learn and use.

The design process should include attention to issues of interactivity across the entire system. This is important for optimal flow of learning and progress through the activities in the system. As well as applying sound principles of *interaction design*, attention should be paid to principles of *instructional systems design* (ISD) (Alessi & Trollip, 2001). In line with principles of ISD, it is important to address the alignment of an e-learning system with ways of achieving its learning goals. Instructional designers are increasingly taking cognitive and motivational principles into consideration and using presentation strategies that support learners' attention and perception. Contemporary interactive multimedia programs provide a combination of learner control and program control.

The next section discusses interactive paradigms.

3.2.2 Interactive paradigms

Over time, systems developers have used different interaction paradigms and a variety of hardware and operating systems to develop interactive applications. The paradigms include *time sharing* and *video display units (VDUs), window systems, WIMP (windows, icons menu and pointing device) interfaces, metaphors* and *hypertext* (Dix *et al*., 2004)*:*

- *Time sharing* resulted in batch processing being replaced by multi-user systems, marking the beginning of non-preplanned activities. V*ideo display units (VDUs)* marked the advent of screens as an alternative to paper-based printouts for presentation of data. These aspects, which brought flexibility to the interaction experience, are now taken for granted, but are mentioned here to provide a background.
- *Window systems* and *WIMP interfaces* facilitate simultaneous interaction by users with several tasks. Icons are graphical symbols that simplify selection of tasks. All these aspects make it easier for users who are not computer professionals to work with computers.

- *Metaphors* brought about supportive techniques that describe and represent a system in a way that helps users understand its operations through the use of easily recognised symbols and analogies.
- The advent of *hypertext* enabled users to browse non-linear text from linked documents.

Other aspects that facilitate interaction are multimedia with its variety of ways of presenting information, and the easily available Internet and World Wide Web (Alessi & Trollip, 2001).

- *Multimedia* extends information presentation by integrating graphics, photographs, video, audio, and animations into electronic documents. The linked hypermedia structure provides search and navigation facilities. It allows users to traverse pages in a non-sequential order and to access definitions or elaborations by clicking on particular links. Multimedia is easy to extend and to update and change.
- The *World Wide Web* (WWW) has increased interaction with systems for users located in different parts of the world. The Internet and the Web have also contributed positively by facilitating access to e-learning. This has been actively achieved through search facilities used for research, e-mail communication between educators and learners, learner-to-learner collaboration, chatrooms, and interactive learning management systems that enable learners to interact with their educators and their study material.

3.2.3 Design principles

Design principles should be the product of integrating theory-based knowledge, experience and common sense (Preece *et al*., 2007). The core design principles include visibility of system status, feedback, mapping and consistency (Norman, 1988). The design of a system should help users in being aware of what is happening (visibility) and should afford appropriate communication back to them (feedback). There is a need for consistency on how the system interacts with the users to guard them from unexpected surprises. Furthermore, there should be hints about the available interaction methods (Norman, 1988). Readability is another design principle that can enhance visibility (Tognazzini, 2003). In the context of e-learning, readability supports the learner in concentrating on the learning rather than being distracted by the system's interface.

3.3 Usability and e-learning

3.3.1 What is usability in terms of e-learning?

Usability is the level of effectiveness, efficiency and satisfaction with which particular users achieve specified goals while using a product in a particular environment (Dix *et al*., ISO 9241-11, 1998; 2004; Preece *et al*., 2007). A system is usable when users can achieve system objectives in different ways that support their progress (Rubin & Chrisnell, 2008). Among the factors encouraged through usability are supportability, as well as training and provision of necessary documentation (Feldman, Mueller, Tamir & Komogortsev, 2009).

Usability relates particularly to the interface of a system and how it assists in interaction with the users. In the case of e-learning applications, learners must be able to use a system, before they can even begin to learn with it. One of the most important goals in the design of an interactive educational system should therefore be the explicit goal of good usability.

E-learning requires a particular form of usability. The interfaces of e-learning applications should make the learning material easily available to intended learners. It should be easy for the learners to concentrate on the learning content without being distracted by the technology used to deliver it. In this context, the content design (pedagogical design) should be suitable for the learning goals. Ardito *et al*. (2006) call for integration of pedagogical aspects into the usability evaluation of educational applications. This should ensure that the content is understandable to learners and based on the intended learning outcomes. Such an approach is in line with learner-centred design (LCD) (see Section 3.3.4.2), which is design that accommodates different categories of learners. Ardito *et al*. (2006) call for inclusion of learning aids based on categories of learners.

Masemola and De Villiers (2006) state that usability in e-learning relates to effective learning and subjective satisfaction on the part of learners, over and above conventional usability. In an e-learning system, efficiency cannot be judged by short times for task completion, because the learning process does not necessarily require rapid progress through the material and tasks. Personal abilities and learning styles are more important than the speed with which the learners do the activities. Another difference from conventional systems is that cognitive errors should be allowed. People learn by their mistakes and these errors do not impact on system usability. However, Masemola and De Villiers advise that there should be feedback and support mechanisms to promote recognition–diagnosis–recovery cycles after learners make cognitive errors. On the other hand, usability errors related to problems in the system, should be diagnosed as problems during the usability evaluation process and corrected.

The next subsection focuses on usability evaluation, with particular mention of e-learning applications.

3.3.2 Usability evaluation

This section refers to usability evaluation in general and to usability evaluation of e-learning applications. Following on this background, specific usability evaluation methods are discussed in Section 3.4.

3.3.2.1 General usability evaluation

Usability evaluation is the procedure of appraising a product to determine how it meets certain identified principles for effectiveness, efficiency and satisfaction to users of that product (Dix *et al*., 2004). It is a continuous process that involves different approaches and should be undertaken throughout a product's development life cycle. Some of the approaches to evaluation, as identified by Preece *et al*.

(2007), include usability testing (see Section 3.4.3); ‘quick and dirty evaluation’ which is a fast and inexpensive way of getting informal feedback about a system from users; field studies (see Section 3.4.2 on observation); and predictive evaluation (see Section 3.4.4 on expert review methods). Preece *et al*. mention these methods in the context of evaluation of conventional systems, not specifically in the context of evaluating e-learning. Further methods, such as surveys by interviews and by questionnaires; heuristic evaluation; and experimental methods, are addressed in Section 3.4.

3.3.2.2 Usability evaluation of e-learning

Regardless of the method being used, the process of usability evaluation can significantly diverge depending on contexts (Greenberg & Buxton, 2008). A case in point is that the evaluation of e-learning applications has its own particular characteristics. There are particular dimensions for usability evaluation of e-learning platforms. E-learning platforms should shield users from unnecessary steps in accessing learning material. Usability evaluation can assess the extent of the support provided by the platform’s interface (Barnum, 2002). Among others, the following dimensions can be investigated in the evaluation of e-learning applications (Ardito *et al*., 2004):

- The *presentatio*n should help learners and educators to see an object or menu item they require. This is done by using analogies and metaphors, for example presenting icons in ways that are related to real-life situations.
- *Hypermediality* can be supported by in-built features of the platform. Specific hyperlinks are used to track the existing links. Users should be able to retrace their path to previous points and should be able to monitor their learning activities. This emphasises the importance of hypermedia tools to manage the hyperlinks and to prevent learners being ‘lost in hyper space’ (Alessi & Trollip, 2001).
- *Application pro-activity* involves the platform and the communication tools that should support learners in achieving their learning goals. Technology should not impose restrictions on the learning process.

- The *learning activities* that learners should perform in order to have full interaction with the learning content should be made explicit, so that learners will know whether or not they are achieving the objectives.

Usability evaluation of e-learning thus requires careful attention to the learners' actual interaction with the system. It is important to check for system problems that may cause learning difficulties as well as those that result in usability problems. In addition, the varying skill levels of the different learners should be taken into account to determine whether the system provides the right kinds of interaction to assist learning by different users.

It should be noted that usability evaluation of e-learning systems is different from that of commercial ones. This is because commercial systems are meant for fast task completion and short execution processes, whereas e-learning applications are intended to support learning through information transfer and to manage educational interaction (Adebesin *et al*., 2009). As mentioned in Section 3.3.1, short times for the completion of learning activities are less important than using personal learning styles, which may be fast or slow (Masemola & De Villiers, 2006). Furthermore, the evaluation of task-based software systems views time spent recovering from errors as a problem, yet Masemola and De Villiers point out that in evaluating e-learning, cognitive errors related to the learning material are allowed, because learners learn from these mistakes. However, usability errors related to system hindrances, should be avoided. Furthermore, a learning application is also course material and, as such should also be evaluated from the perspective of its learning content and pedagogic strategies

3.3.3 Usability principles

The primary goal of usability is achieving efficiency, effectiveness and user satisfaction. To achieve this, Dix *et al*. (2004) propose three main usability principles, namely: *learnability*, *flexibility* and *robustness*. Although these were not developed specifically as evaluation criteria, they are relevant both to design and evaluation, and are therefore included in this chapter.

3.3.3.1 Learnability

Learnability relates to how easily new users can start effective interaction with a system and reach optimal performance (Dix *et al*., 2004). Learnability is supported by five sub-principles:

Predictability within an interactive system supports users in using their experience of past interactions to determine the effect of the next and future actions. It should be noted that novice users' expectations differ from those of experts' expectations. The *synthesisability* principle aids the user in assessing the effect of past actions and operations on the current system state. This assumes that the user has a mental model of system behaviour. *Familiarity* relates to the extent to which the knowledge of other systems and experience of users in the real world helps them to interact with a new system. It also takes into account how users expect to see things taking place in that environment on their first encounter. The principle of *consistency* is about comparison between systems of the input/output behaviour that arises from similar situations or similar task objectives. A system consistent with common practice should provide a given level of expectation to its users. *Generalisability,* which is related to predictability and consistency, is the final sub-principle of learnability. It provides assistance to users in extending their knowledge of specific interaction within and across systems to other similar scenarios. To achieve this in a system, it is prudent to look at similar systems to determine what they accomplish and how they do so.

3.3.3.2 Flexibility

Flexibility is about different ways of interaction between the users and the system. The principle is supported by sub-principles as follows:

Dialog initiative offers users freedom from constraints on input dialogue. Dialogue can be initiated by the system, with the users responding, or the users can be free to initiate an action or activity. *Multi-threading* supports the capability of the system interface to enable users to access more than one task at a time. *Task migratability supports* the users in internalising the system's execution controls. This control can still be shared between the system and its users. *Substitutivity* facilitates the use of equivalent values of input/output alternatives for one another. The users are not restricted to specific ways of performing tasks. The concept of *customisability* enables users to modify the user interface of a system. For instance, it is likely that users might customise systems to be able to use some internationally recognised metrics and others that suit their regions.

3.3.3.3 Robustness

Robustness is the resilience of a system when put under stress or when confronted with invalid input. Robustness of a system's interaction should include support for users to successfully achieve and assess their goals (Dix *et al*., 2004), which in itself is goal completeness. Robustness is supported by the sub-principles briefly discussed below:

Observability is a principle that supports users in tracking a system's internal state from the representations of system status. This supports the users in browsing through the system and knowing what is taking place within it. *Responsiveness* refers to how users understand the communication with the system (Dix *et al*., 2004). A responsive system is likely to be stable since the users can adequately communicate to it. Systems with good response rates can handle high numbers of tasks that at times may be complex. *Recoverability* supports robustness by enabling necessary remedial action in a system to guard against compromised integrity of system data. The principle of *task conformance* enables a system to support the tasks that the users require to be accomplished through to completion. By so doing, the users should be able to understand how the system achieved such completion.

These principles and sub-principles of usability proposed by Dix *et al*. (2004) are intended to improve usability. In the case of educational software and web-based learning, application of the principles should support users by improving their ease of learning.

The section that follows specifically addresses the usability of e-learning applications.

3.3.4 Usability of e-learning

In Section 3.3.1 it was mentioned that usability in the context of e-learning cannot be considered identical to usability in the context of conventional software. This subsection explains further.

3.3.4.1 Aspects of usability in the context of e-learning

Usability of e-learning systems involves both *technical usability* and *pedagogical usability*. Technical usability is about techniques to ensure that an interaction with a system is trouble-free, while pedagogical usability intends to support the processes of teaching and learning (Melis & Weber, 2003). To achieve pedagogical usability, the design team of an e-learning application should consider detailed issues of human learning, learning goals and processes, as well as the usual aspects of system requirements and usability. Particular attention should be paid to ways in which e-learning activities can support users in learning complex sections of the material.

Usability in an e-learning system should address the following (Melis & Weber, 2003):

- A framework can be provided to support learners in developing a coherent mental model of the system. The framework should be adaptable to support the learning process.
- Different types of learner support can be offered to meet different learning needs, for example guided tours to introduce what the system offers and detailed, easily-available help for reference purposes.
- On-screen texts should be short and precise, because reading on a screen is different from reading a book.

Furthermore, Muller (2002) recommends specific criteria for usability of e-learning systems:

- The design should ensure that help is readily available for the user. For example, where unfamiliar words are used, they could be highlighted and have links to a glossary. Site design should use regions on the screen in ways that focus the learners' attention on key issues. The pages should have rapid download times.
- Navigation should be simple. The hyperlinks should direct learners to the appropriate content, using colour changes to enable a learner to recognise whether a link has been used. There should be backward links to return learners to where they started.
- If the system has an underlying behavioural ethos, the learning objectives should be clearly stated and the extent to which they are acquired by learners should be measurable.
- The content should be organised and sequenced in line with the learning objectives. The most important content should be placed prominently on the pages.
- There should be good balance in the use of graphics and text to avoid distracting the learners.

Learner-centred design (LCD) plays an important role in the usability of an e-learning system. This is discussed in Section 3.3.4.2.

3.3.4.2 Learner-centred design

Learner-centred design (LCD), mentioned in Section 3.3.1, approaches the development of a system with the needs of the learners at the forefront. LCD should also include structures for feedback, error prevention, error recovery, avoidance of cognitive load and online help, among others (Ardito *et al*., 2006). Ideally, LCD requires the inclusion of learners' feedback in the formative stages of development, so that their input can be used in the design. Learners can be involved at different stages of the design process and, if need be, in the whole process (Good & Robertson, 2006).

The key objective for user-centred design, as observed by Nielsen (2003), is the acquisition of knowledge that is aligned to users' real needs and not primarily focused on learning technical aspects of a system. System-based guidance can enhance operation of a system by simplifying the process of initial use, and thus improve user efficiency (Singh & Wesson, 2009).

The matter of usability evaluation was briefly mentioned in Section 3.3.2. The next subsections discuss various usability evaluation methods.

3.4 Usability evaluation methods

The definition of usability was discussed (in Section 3.3.1) with the intention of understanding it within the context of e-learning. Various usability evaluation methods (UEMs) are available. Some of them are based on experts' judgements and others on users' feedback. For instance, usability inspection, such as heuristic evaluation, is conducted by a group of experts who rely on a set of principles known as heuristics to assess a product (Barnum, 2002; Dix *et al*., 2004; Nielsen, 1994c; Nielsen & Mack, 1994). The cognitive walkthrough is another method that requires the skill of experts, who carry out a detailed review of a sequence of actions, with information about the users, the systems and the task (Barnum, 2002; Dix *et al*., 2004). User-based methods, on the other hand, include surveys done by questionnaires or interviews, as well as different kinds of observation of users interacting with systems (Dix *et al*., 2004; Preece *et al*., 2007).

The subsections that follow discuss general usability evaluation methods (UEMs), most of which can also be used for evaluating e-learning systems. As mentioned in Section 3.3.2, Preece *et al*. (2007) name certain evaluation paradigms, namely: usability testing, 'quick and dirty' evaluation, field studies and predictive evaluation.

The data that is collected by the UEMs during usability evaluation is frequently qualitative (Feldman *et al*., 2009).

This literature review in Section 3.4 introduces a variety of UEMs, but it should be noted that the empirical studies in the present research apply user questionnaire surveys and controlled usability testing as its UEMs. These two methods are described in Section 3.4.1.1 and Section 3.4.3 respectively.

3.4.1 User surveys

The design of a user survey depends on the purpose of the survey and the sample of the user population. The questionnaire or interview should include a diverse range of questions. Furthermore, the questions should be friendly and focused on issues that are understandable to the respondents. The design of the survey should promote trust between the evaluator and the respondents (Dillman, 2007). Surveys can be conducted using questionnaires and/or interviews. Both the questionnaires and the interviews are query techniques that involve interacting with participants to get their opinion about a system (Dix *et al*., 2004). Unlike usability testing, they are carried out in non-controlled environments. This section discusses the two user survey methods.

3.4.1.1 Questionnaires

The use of questionnaires requires the evaluator to prepare pre-set questions that are administered on a wider user population or can be administered to a sample of users (Barnum, 2002; Beatty & Herrmann, 2002; Dix *et al*., 2004). The questionnaire method can also be used alongside other methods such as usability testing or heuristic evaluation. A questionnaire can be made up of questions that are closed or open in their structure (Preece *et al*., 2007). When employing a user survey to evaluate educational application software, there should be an emphasis on how it supports the learning process. Therefore, certain questions should relate to learner needs and learning objectives.

The following guidelines can be used to develop questionnaires (Preece *et al*., 2007):

- Use clear and specific questions.
- When asking closed questions, offer a wide range of options from which participants can pick their answers.
- Include a neutral opinion option for questions seeking participants' opinions.
- Order the questions appropriately since the order is likely to influence the participants.
- Difficult words and phrases in the questions should be avoided.
- Provide clear instructions on how the questionnaire should be filled in.
- Be considerate regarding the length of the questionnaire (if it takes too long, participants may become tired or bored and make less effort).
- The ordering of the Likert (or other) scales used, should be meaningful and consistent throughout the questionnaire.

Questionnaires are commonly used and often preferred because they can reach a broader group, and are inexpensive and easy to administer (Dix *et al*., 2004). In this research, questionnaires are used as one of the two main UEMs.

3.4.1.2 Interviews

The interview method enables the evaluators to interact with the users of a system by asking usability-related questions about their experience when using the system (Dix *et al*, 2004). Just as for questionnaires, interviews can be used alongside other methods, such as direct observation or as a follow-up to questionnaire survey to obtain additional information on certain aspects. Questions can also be asked after a usability testing session to capture more information from the participants.

Interviews should be planned in advance to enable the facilitator to compile questions that focus on the objectives of the interview (Dix *et al*., 2004). Preece *et al*. (2007) provide some guidelines about designing questions for interviews:

- Avoid long questions. Short questions are easier for the participants to understand.

- The questions should be clear, simple and easy to answer.
- Difficult words and phrases should be avoided.
- Avoid the use of leading questions, since this may discourage participants from answering to the contrary.
- Personal biases of the interviewer should not be conveyed to the interviewees.

3.4.2 Observation

Observation methods include field studies and controlled usability testing.

The advantage of a field study is that it does not take place in a controlled environment. This UEM increases the researcher's understanding of how users interact with a system in its natural setting (Preece *et al*., 2007). This ethnographic approach holds relevance for the improvement of product design, as it helps in identifying gaps and indicates opportunities for new technology. It also determines requirements for design of new products and systems. The upfront identification of problems can be used to facilitate the introduction of technology.

The section that follows discusses usability testing which is a main UEM in the present research.

3.4.3 Usability testing

Usability testing is the procedure of learning from users' experiences about the usability of a product or application by observing them using it (Barnum, 2002; Barnum, 2008). It is a software evaluation technique that assesses a product's usability by observing how the participants use it and noting the errors that they make (Barnum, 2008; Masemola & De Villiers, 2006; Zazelenchuk, Sortland, Genov, Sazegari & Keavney, 2008). It involves observing and monitoring users at different stages of design, development and use of a system (Tohidi, Buxton, Baecker & Sellen, 2006). The testing is normally conducted using sophisticated equipment in the controlled environment of an HCI laboratory (Dix *et al*., 2004; Rubin & Chrisnell, 2008). This approach enhances reliability (Adebesin *et al*., 2009). Different usability testing methodologies exist and there are varying opinions about their effectiveness and practicality (Au, Baker, Warren & Dobbie, 2008).

According to Nielsen (1994c), usability tests should ideally be conducted with real users as participants. This provides the evaluators with direct information on the usability status of the application when in operational use. As an evaluation paradigm, usability testing of a system entails measuring real or stereotypical users' performance on specified, observed tasks that are typical of the ones for which the application was designed (Preece *et al*., 2007). These empirical aspects of usability testing are discussed in Section 3.5. Although usability testing focuses on the collection of usability metrics and on understanding the learners' experience during defined sessions (Barnum, 2008), the emphasis is on testing the software and not on testing the users, and the participants should be informed of this. During a testing session, the users can also be video- and audio-recorded for reviewing, which facilitates future analysis of the data (Hannafin, Shepherd & Polly, 2010).

There are basic elements of usability testing and its sessions, as presented by Rubin and Chrisnell (2008):

- Use of test objective and not hypothesis
- Use of a representative sample of stereotypical users
- Observation of test participants during the testing sessions
- Controlled interviewing and probing the test participants after the testing sessions
- Collection of quantitative and qualitative data
- Recommendations based on the results of usability testing sessions.

Different metrics can be used to measure the users' performance. These include (Dix *et al*., 2004; Preece *et al*., 2007; Stone, Jarret, Woodroffe & Minocha, 2005):

- Time taken to complete a task
- The number of errors made while doing a task, and the type of errors
- Time taken to recover from errors
- The number of errors per unit of time
- The number of times a user navigated to a Help function or manual
- The number or percentage of users who completed the task successfully
- The error messages that appeared.

Other possible usability measures include (Dix *et al*., 2004; Stone *et al*., 2005):

- Number of commands used
- Number of good and bad features that user recalled
- Number of available commands that were not invoked
- Number of interfaces that misled the users.

In some cases, there may be a need for a baseline test to determine the fluctuation from the expected average measures (Sperry & Fernandez, 2008). This can be done during the first task. At the beginning of a usability testing session, the participants should be required to do simple tasks to help them build confidence in the user testing process. Thereafter, as recommended by Nielsen (1994c), tests with tasks that produce tangible results can be introduced.

Laboratory testing is thus a method whose key characteristic is the *strongly controlled* evaluation environment (Mayhew, 1999). A good arrangement of test instruments contributes to more reliable results (Huang, Bias, Payne & Rogers, 2009). The tests are effective in identifying problems and inadequacies. The results can be used to make improvements and enhance the usability of products (Dumas & Redish, 1999; Jeffries, Miller, Wharton & Uyeda, 1991). Kuniavsky (2003) suggests that usability testing should start as soon as possible in the system development cycle and that the system developers should be involved in deciding on the target audience and features to be examined.

The procedures involved in laboratory testing commence with preparation by the researcher of test material, which includes a list of activities. During the preparation of the list of activities, the test administrator decides on what would need to be done during and after the tests. The statement should be a clear description of what is being tested. It should include a task list of the main tasks to be performed by participants. Before conducting a testing session, the tasks themselves should be tried out in a pilot study, to confirm that the task list makes sense to the participants and that the tasks are relevant.

It is important that there should be minimal disruption during a testing session. At the end of the test, the test administrator may use the opportunity to capture more information. This can be done through brief questionnaires or by debriefing discussions. In addition, depending on the usability problems identified, the test administrator might develop an implementation plan for the proposed solutions.

Usability testing is normally characterised by non-manipulation of variables. This is partly why Nielsen (2000) recommends that the number of participants in a usability test should be limited to five. He suggests that as evaluators add more users, they may learn less as they keep seeing similar behaviours from the additional users. Dix *et al*. (2004) stress the use of a good representative sample for the evaluation to be reliable and valid and propose at least ten participants for usability testing. Hwang and Salvendy (2010) believe that between eight and twelve participants are required to identify about 80% of usability problems. This is the approach adopted in the present study, where 12 participants were used for the usability testing (see Section 6.5.4).

It is important that the consent of participants should be sought before the start of usability testing. The participants should be briefed on what occurs in the evaluation session, before they are requested to complete informed consent forms. The briefing should explain the type of questions to be asked, tasks to be carried out, and the duration of the sessions. The participants should be assured that the system is being tested and not them. The assurance and explanation should be given before they sign the consent forms (Lee, 1999).

3.4.4 Expert review methods

Expert review methods include predictive evaluations in which experts apply their knowledge of users to foresee usability problems (Preece *et al*., 2007). It involves predicting the aspects, instead of observing them directly from users. The following methods presented by Shu and Furuta (2005) can be used to carry out predictive evaluation:

3.4.4.1 Usability inspections

This investigates the interaction dialogue between a single user and the software. Standard inspection involves experts examining the software for compliance with specified standards. Consistency inspection involves the design team conducting an inspection of a set of interfaces for a range of software products. Such an exercise aims at tracking consistency within a range of products.

3.4.4.2 Usage simulations

This method involves an assessment of the software system to identify any usability problems. Experts, who can simulate the behaviours of normal users, usually do this type of evaluation. Shu and Furuta (2005) further mention that usability problems may be identified by the experts in the form of inconsistency, poor task structure and confusing screen design, amongst others.

3.4.4.3 Structured expert reviewing

As a reviewing method, structured expert reviews involve conducting a detailed overview of specific planned and structured tasks. The method is known to be more prescriptive in nature and more focused than methods that attempt usage simulations (Shu & Furuta, 2005).

3.4.4.4 Modelling

The modelling technique requires specification of a system's functionality and task analysis. A model looks at almost all important elements of the specified system. Flaws in the model are likely to transfer such flaws to the system being developed within the model's context.

With the above background about different usability paradigms, the next section focuses on the different models, some of which are developed within those paradigms. Expert review methods also include heuristic evaluation which is important for CAI systems. Heuristics and heuristic evaluation are addressed in the next section, Section 3.4.5, as well as in Chapter 4, where heuristics are discussed in Section 4.3.2 on concepts of *e-learning applications.*

3.4.5 Heuristic evaluation

This usability evaluation method is carried out by usability experts, who study various aspects of the target system and compare them with a set of evaluation criteria termed 'heuristics'. The focus is on identifying factors that could cause usability problems (Jeffries *et al*., 1991). The expert evaluators are normally provided with a list of guidelines that they use to explore the system's interface to check for any violation of the heuristics. Evaluation of an application based on such a set of heuristics, helps to identify potential usability issues (Dix *et al*., 2004). The evaluator's prior experience with usability is therefore important, if he/she is to be a true *expert evaluator*. To obtain good results, it is recommended that each evaluator conduct an independent evaluation. Its main emphasis is on error prevention and user control, which are very important for an educational system, but the approach can also be used to identify a system's appropriateness for users' needs (Nielsen & Mack, 1994).

The following are the heuristics originally presented by Nielsen (1994c) who proposed that the software should:

- Use simple and natural dialogue
- Speak users' language
- Minimise users' memory load
- Characterised by consistency
- Provide good feedback
- Have clearly marked exits
- Offer shortcuts or accelerators
- Present good error messages
- Support prevention of errors
- Provide good help and documentation.

The heuristics were revised by Nielsen and Mack (1994) and have also been adapted by researchers such as Squires and Preece (1999) and Singh and Wesson (2009). In this study, they are adapted to contribute to the evaluation of e-learning applications. An elaborate set of Nielsen's heuristics is listed in Section 3.6.2 which presents usability evaluation criteria.

For reliable feedback from heuristic evaluation, Nielsen (1994a) recommends three to five evaluators as being sufficient. He believes that additional evaluators are unlikely to find further factors that the five would not have identified. Moreover, heuristic evaluation is commonly known to detect more usability problems when compared to other available techniques (Jeffries *et al*., 1991). This is, however, dependent on other factors such as the expertise of the evaluators and the environment of the evaluation.

3.4.6 Experimental methods

The experimental model is widely accepted and used in evaluation and research in the context of education and training. However, the following are some associated problems (Reeves & Hedberg, 2003):

- Control of treatment variables, as required by experimental methodologies, is impractical in most situations where learning systems are evaluated.

- Emphasis on measuring educational outcomes by testing use of a system is rarely matched by an associated effort to establish the reliability and validity of the measures.
- The pure experimental approach can be used to test pre-stated hypotheses, but it cannot discover unexpected effects of a product within an instructional context.
- Randomised experiments are extremely difficult to carry out and can be unethical in some cases.

3.5 Aspects of empirical evaluation studies

This section discusses some empirical aspects of usability evaluation that are relevant to this research. By its nature, usability testing is expensive because it uses sophisticated equipment and it is normally conducted on one participant per test session (Lindgaard & Chattratichart, 2007). Usability testing that is correctly conducted is likely to identify major usability issues (Au *et al*., 2008). When applying empirical approaches to measuring usability, efforts should be made to identify actual usability problems that are encountered by real users (Schmettow & Vietz, 2008).

3.5.1 Empirical evaluation process

During an experimental evaluation, it is important to minimise how variables are likely to influence the results (Preece *et al*., 2007). The control of variables on the system's interface and their effect on user's performance should be stressed (Preece, 1994). This also places importance on the choice of subjects (participants), test variable and hypotheses (Dix *et al*., 2004).

Where possible, the participants in an empirical evaluation should be real users. Alternatively, the choice of participants should be close to a sample of real users.

An empirical evaluation normally uses independent variables and dependent variables. Independent variables are those that are manipulated to generate different comparisons. Values of the dependent variables are measured to determine the impact of the independent ones (Dix *et al*., 2004).

The success of an empirical evaluation depends on its planning. Preece (1994) recommends the following for the planning and conducting of empirical evaluations:

- Use of clear statements on the objectives of the evaluation including the variables to be used,
- Use of testable hypotheses or good research questions, and
- In the case of quantitative data, statistical tests should be conducted to ascertain the reliability of the results obtained.

3.5.2 Norman's interaction model

Norman's execution-evaluation cycle as outlined in Dix *et al*. (2004) emphasises the evaluation process. The cycle's two main parts are the execution and the evaluation phases whereby the *gulf of evaluation* is the distance between the presentation of the system and the user's expectations. The two phases of the cycle have a total of seven stages.

a) The stages for the *execution* phase:

- Establishing a goal,
- Forming the intention,
- Creating the plan, and
- Executing the plan.

b) The stages for the *evaluation* phase:

- Perceiving the system state,
- Interpreting the state, and
- Evaluating the state.

The stages of this model can provide a cost effective framework for gathering information during a usability evaluation. This requires the establishment of the goal and nature of an evaluation to guide the activities.

In view of the above discussions, Section 3.6 focuses on usability evaluation criteria.

3.6 Criteria for usability evaluation

Usability heuristics are, by definition, used in heuristic evaluations, but the term, *usability criteria,* is also used. Before setting up a user survey to evaluate usability, usability criteria should be established as a foundation for the questions and evaluation statements. Usability criteria are helpful in questionnaire and interviews in identifying usability problems, but must be directly relevant to the study in hand.

Guidelines and criteria for the evaluation in present study are discussed in detail in Chapter 4, which is called *Criteria and framework for usability evaluation of e-learning software*. This section introduces various sets of evaluation criteria.

3.6.1 Performance measures for usability evaluation

The performance measures in usability testing are also known as the usability metrics. For evaluating educational systems such as e-learning tutorials, the metrics relate to learners' performance on the system so as to assess the interfaces and interaction design of the target system. Usability measures advocated by Dix *et al*. (2004) are listed in Section 3.4.3 on usability testing. Certain metrics for measuring usability of a system as identified by Nielsen (1994c) and Au *et al*. (2008) overlap with Dix's set and extend it:

- Time taken by users to complete a task
- Number of tasks completed within a given time limit
- Ratio between successful interactions and errors

- Number of user errors
- Types of errors
- Time taken recovering from errors
- Frequency of use of the help facility.

The next section briefly presents different categories of evaluation criteria

3.6.2 Nielsen’s evaluation heuristics/criteria

Nielsen’s heuristics for heuristic evaluation were discussed and presented in Section 3.4.5 on heuristic evaluation, but are listed below in an elaborated form (Nielsen & Mack, 1994):

1. *Visibility of the system status:* During interactive sessions, the learners need to know in which part of the system they are currently located. This can be achieved through well-indicated options of operations that they can perform to move to the next step.
2. *Match between the system and the real world:* Icons or metaphors that are used in the system should correspond to concepts that are familiar to the users from their real-world experiences. The system should *speak the users' language* by using familiar names, phrases and symbols.
3. *User control and freedom:* A system's interface should provide the users with some control on how to carry out certain operations such as adjusting settings and exiting the system. Furthermore, the interface should ease the way in which users can leave an error situation.
4. *Consistency and standards:* A system should present its interface and content in a consistent way. This would enable users, who have used similar systems elsewhere, to feel that the features of the new software are familiar.
5. *Error prevention:* A system should guard the users against making errors. Error prevention can be built into the system, and users should be informed why a certain operation was prevented by the system.

6. *Recognition rather than recall:* Frequently used interfaces should be visible and easily recognisable. In the situation where the users may have forgotten how to perform a specific action, then simple cues or instructions on how to proceed should be readily available.
7. *Flexibility and efficiency of use*: Users appreciate a system that any category of user (novice, intermediate or expert) can operate with ease. For instance, shortcuts that speed the work of expert users can be available, yet remain hidden from novices.
8. *Aesthetic and minimalist design:* It is recommended that the interfaces should present only the information that is relevant in the context of users' operations and tasks.
9. *Help users recognise, diagnose, and recover from errors:* In cases where a user executes an incorrect operation, there should be short and clear error messages that are easy to understand.
10. *Help and documentation:* These provide vital assistance to users. Such information should be highly visible and directed to the user's need at that point in time.

These heuristics can apply to evaluation of general software and, to some extent, to learning systems. However, the requirements for learning systems are specialised and there should also be an emphasis on learners and learning objectives. Various researchers took Nielsen's classic heuristics as a basis and modified them for evaluation of e-learning applications.

3.6.3 Usability evaluation criteria specifically for e-learning applications

Usability evaluation criteria can be placed in different categories depending on the use and intended purpose or according to the researcher/s who generated them.

3.6.3.1 Squire and Preece heuristics

Criteria for evaluation of learning systems should also stress the achievement of learning objectives. Squires and Preece (1999) adapted Nielsen's heuristics (given above in Section 3.6.2) to customise them to pedagogical aspects of educational systems (Squires & Preece, 1999). They are discussed further in Chapter 4, Section 4.3.2 which focuses on the research design of the present study. With regard to error prevention, Squire and Preece point out that design of e-learning systems should prevent peripheral usability errors while allowing users to make cognitive errors related to the subject matter being learned.

Squires and Preece further identify *credibility*, *complexity*, *ownership* and *curriculum* as being important to cognitive authenticity. Credibility has its emphasis on feedback and design, cosmetic authenticity, representation forms, and interaction flows. Complexity deals with the ease of navigation, representation of the real world, pedagogical techniques and learner support material. Ownership discusses learner control and interfaces that support learning needs. Curriculum is about subject content and educators' customisation to support learning.

These factors are relevant to the evaluation of e-learning tutorials such as the target system in this study and are addressed further in Chapter 4 (Section 4.3.2) in the context of developing suitable criteria for usability evaluation of *Instap!E4B*. The pioneers of evaluating e-learning, Squires and Preece (1999) present the following heuristics for usability evaluation of what they then termed 'educational software':

1. *Match between designer and learner models* involves considering intrinsic feedback in a manner that supports consistency between the learners' and the designers' models.
2. *Navigational fidelity* calls for the interface design to provide the required usability by availing simple representations and appropriate paths through the system and its activities.
3. *Appropriate levels of learner control* should be provided by learning systems where there is a relationship between learner control, learner-direction, customisation, consistent protocols, and system control.

4. *Prevention of peripheral cognitive errors* relates to complexity and prevention of usability errors. This should give freedom to learners to make content-related mistakes that assist in the learning process.
5. *Understandable and meaningful symbolic representation* should be used in learning systems to encourage recognition rather than recall.
6. *Support for personally significant approaches to learning* is necessary through multiple representations and learner support materials.
7. *Strategies for cognitive error recognition, diagnosis and recovery* should support learners in noticing when they have made content-related mistakes and how to get out of such situations. This can be done through cognitive conflict, scaffolding, and bridging that are techniques for recognition, diagnosis and recovery.
8. *Match with the curriculum* ensures that a learning system is appropriate to the curriculum. Where possible, customisation should be done by educators.

3.6.3.2 Albion's heuristics

Albion (1999) presents heuristics/criteria in three categories.

1. *Interface design heuristics*

The first category is based on Nielsen (1994a) and relates to the user interface of the system.

- Ensure visibility of system status
- Maximise match between the system and the real world
- Maximise user control and freedom
- Maximise consistency and matches standards
- Prevent errors
- Support recognition rather than recall
- Support flexibility and efficiency of use
- Use aesthetic and minimalist design
- Help users recognise, diagnose and recover from errors
- Provide help and documentation

2. *Educational design heuristics*

The heuristics in the second category are based on Quinn's (1996) heuristics, and mainly focus on the educational aspects of learning systems. They were compiled for heuristic evaluation, but are also applicable to evaluation by other UEMs, such as surveys.

- The goals and objectives should be clear
- The context must be meaningful to domain and learner
- Content should be clearly represented and different ways and paths for navigation should be provided
- Scaffold the learning activities
- Elicit learners' understanding
- Formative evaluation should be conducted.
- Performance should be criterion-referenced
- The learning should be transferable to other learning domains and should help learners acquire self-learning skills
- The system should provide support for collaborative learning

3. *Content heuristics*

The heuristics in the third category are designed to evaluate the content and learning material in the context of meeting the learning objectives.

- The context should be established and suitable content be provided
- Content should be relevant to professional practice
- Professional responses should be presented to issues
- Reference materials must be relevant
- Video resources should be available
- Assistance should be supportive rather than prescriptive
- Materials should be engaging.

These sets of heuristics are discussed in Section 4.3, and are used in the development of the framework of criteria synthesised by the researcher to evaluate the CD-based interactive tutorial that is the target system of this study.

3.7 Summary and conclusion

This chapter presented e-learning and usability evaluation as important aspects to be studied in the process of achieving the objectives of the study. It showed the relevance of interaction design in making a system usable to the intended users (see Section 3.2). This was further emphasised in Section 3.3 that discussed usability and e-learning, with learner-centred design being vital for learning systems. The discussion showed that learner-centred design involves instructional and interface design principles. Furthermore, the chapter noted that good interfaces, usability and sound educational design are necessary for development of educational software. In Section 3.4, different usability evaluation methods were discussed with a view to understanding them and indicating which UEMs are applied to this study. Some aspects of empirical evaluation were discussed in Section 3.5 showing the importance of clarity during the empirical evaluation process to achieve the intended results. The chapter was consolidated in Section 3.6 with a discussion of general usability evaluation criteria and presentation of heuristics/criteria specifically designed for e-learning applications.

The chapter as a whole showed that e-learning needs to offer usable and relevant learning content. In addition, the conventional criteria for usability should be met in order to support learners in using the system to achieve the learning objectives.

A major contribution of Chapters 2 and 3 is that they lay foundations for Chapter 4. Chapter 4 presents a synthesised framework of criteria for usability evaluation of e-learning and extracts a set of criteria customised for the evaluations in this study. The latter criteria are used in the two empirical evaluation studies conducted in this research and described in Chapter 7.

Chapter 4: Criteria and framework for usability evaluation of e-learning applications

4.1 Introduction

As already mentioned in this study (Sections 3.3.1 and 3.3.4), usability evaluation of learning systems is different from evaluating conventional electronic computing applications. E-learning applications, as defined in Chapter 2, are computer-based applications that are available on different media, such as CD-ROMs, online on intranets, or on the World Wide Web. Different kinds of applications facilitate the acquisition of knowledge in different ways, based on their intended objectives (Alessi & Trollip, 2001). They support learning using a variety of computer-based tools and educational technologies (Balasundaram, 2011). Therefore, specific considerations must be taken into account when developing criteria to evaluate particular kinds of systems.

Masemola and De Villiers (2006) point out that, in the context of evaluation by usability testing method, conventional usability testing may not optimally judge learning applications since e-learning applications are focused more on processes than on generation of products, the main process being the learning process undertaken by users. Masemola and De Villiers further observe that:

- Low times taken on tasks cannot be used to assess usability, since some learning disciplines do not require rapid progress through learning content or tasks. The time taken may depend on an individual's learning style.
- Cognitive errors should be acceptable when using an e-learning system, since they add value to the learning processes. Learners can learn from making these mistakes and recovering from them.

- The focus of evaluation by usability testing should be on testing usability rather than testing the system's functionality. Usability errors caused by weaknesses in the system should be identified and eliminated.

Evaluation criteria are standards and requirements used in identifying usability problems in a system (Dubey & Rana, 2011). This chapter sets out evaluation categories and criteria for investigating e-learning applications and thus answers Research Question 1 of the study, namely, '*What are appropriate criteria for evaluating an e-learning tutorial?*', as set out in Section 1.4. In particular, a set of criteria should be identified that is suitable for evaluating stand-alone interactive tutorials, since the target system evaluated in the case study is a CD-based tutorial.

In Section 4.2 the discussion is about the relationship between instructional design and human-computer interaction. Section 4.3 presents some of the early heuristics and guidelines for evaluating electronic educational learning systems. A broad synthesis of evaluation criteria for e-learning applications is undertaken in Section 4.4, while the specific criteria selected for use in this study are presented in Section 4.5. The chapter is concluded in Section 4.6.

4.2 Human-computer interaction and instructional design

From instructional design, it is evident that e-learning applications and instructional software systems are different from conventional task-based systems. The designing of effective activities that are consistent with the learners' tasks should precede development of a learning system (Squires, 1999). The design of an e-learning tutorial should ideally include some aspects of the constructivist approach and should stimulate creativity among the learners (Squires & Preece, 1999). However, it is acknowledged that e-learning tutorials are mainly behaviourist in nature and, in most cases, this is an appropriate way of communicating well-structured subject matter.

Usability of a system is related to its contextual uses and thus it is important that the participants in an evaluation are a true reflection of the intended population (Davis & Shipman, 2011).

From the perspective of HCI, e-learning applications should conform to certain standard usability attributes such as navigation control and feedback mechanisms, as set out in Sections 4.3.1 and 4.3.2. Beyond this, however, it is essential that the designs should not impede learning and thus Squires (1999) calls for usability features that integrate smoothly with educational design. The design of e-learning applications should therefore prevent peripheral usability errors while allowing cognitive errors (Squires & Preece, 1999), as mentioned in Section 4.1.

4.3 Early heuristics and guidelines for the evaluation of educational systems

Jakob Nielsen (Nielsen, 1994b) was a pioneer of usability evaluation. He advocated methods such as heuristic evaluation and usability testing to find usability problems in systems. His research was not in the context of educational systems, but his ten classic 'Nielsen's heuristics' (Sections 3.4.5 and 3.6.2) have formed a basis for usability evaluation in general.

In the early days of CAI, educators evaluated educational technology with checklists, but the development of educational systems did not include a formal evaluation component. This section presents some of the early efforts that address usability aspects as well as educational factors.

4.3.1 Evaluation questions for educational software

In an early version of usability heuristics of e-learning, then so-called 'educational software', Squires (1999) proposed evaluation questions that should be answered when designing educational systems. These are as follows:

- Is the complexity level of the environment appropriate?
- Is the learner active?
- Is fantasy used in an appropriate way?
- How appropriate is the content to the curriculum?
- How navigable is the software?
- What sort of learner feedback is provided?
- What is the level of learner control?
- Are learners motivated when they use the software?

The next subsection broadens the above and discusses further pioneering guidelines for evaluating educational technology.

4.3.2 Heuristics for learning with software

Squires and Preece (1999) were pioneers of usability evaluation of educational technology applications. It has already been described in Section 3.6.3.1 how they took Nielsen's heuristics as a foundation to develop what they called heuristics for 'learning with software'. In addressing usability of 'educational software', Squires and Preece identified important concepts of cognitive authenticity, namely *credibility*, *complexity* and *ownership*.

4.3.2.1 Credibility

Credibility means that the results of a usability evaluation are valid and free of distortion. If the results of an evaluation are to be credible, factors such as those listed below should be investigated (Squires & Preece, 1999).

- *Feedback and designer/learner models:* In designing tasks and activities, the design and the feedback should focus on supporting learning and not hindering it.
- *Cosmetic authenticity:* Despite the value of multimedia, designers should avoid multimedia features that might distract learners.
- *Representational form:* The interface should promote the learning process by enabling learners to easily find features that are related to the intended learning outcomes.
- *Multiple views/representations:* Different representations to support different learning styles should be used to encourage creativity in learning experiences.
- *Interaction flow:* There should be free-flowing user interaction, and feedback should be helpful but not an obstacle to learning.

4.3.2.2 Complexity

The application should guide learners clearly through scenarios that involve complexity. This is addressed by the following heuristics (Squires & Preece, 1999).

- *Navigation:* The navigation system should offer flexibility to the users.
- *Representation of the real world:* Where metaphors are used, they should have similarities with the real world.
- *Symbolic representation:* The use of symbols and icons should communicate meanings that the target learners understand.
- *Cognitive errors:* Cognitive errors that occur as a result of trying to understand a concept, are encouraged. This type of mistake can strengthen the learning process.
- *Pedagogical techniques:* Similarly, the learning tasks should be tolerant of learners' mistakes. Certain mistakes enrich learning, due to the need for learners to identify the processes that caused the error.

4.3.2.3 Ownership

Learners should have personal ownership of the learning process by being able to dictate the pace of learning. For ownership, the following aspects are important (Squires and Preece, 1999).

- *Learner control:* Learners should be able to control their learning by charting their direction and pace.
- *Tailoring the interface:* Some interfaces should be customisable by the learner. This can enhance learning by meeting personal requirements.

Squire and Preece consolidate their criteria into eight heuristics for ‘learning with software’. Those have been listed in section 3.6.3.1.

4.3.3 Albion’s heuristics

The work of Albion (1999) was introduced in Section 3.6.3.2. Albion (1999) proposes heuristics to evaluate various aspects of e-learning applications. They are categorised into three groups of heuristics relating respective to:

- The user interface
- educational design, and
- content-related heuristics which evaluate learning content in the context of meeting the intended learning objectives.

The three categories are detailed in Chapter 3. The heuristics that are most relevant to the purposes of this study are extracted from Section 3.6.3.2 and from (Albion, 1999):

- *Clear goals and objectives:* An educational system needs to have clear goals that a learner should have achieved upon completion of a learning session.
- *Subject content:* The subject matter of a learning system should address key requirements of the curriculum.
- *Relevance of materials:* The content and its packaging should be relevant to the learning scenarios and at a level appropriate to the learners.

- *Engaging materials:* The presentation style and content should be engaging and should encourage learners to complete a learning session.
- *Support for transfer and real-world skills:* Learning systems should enable learners to transfer the learned skills and use them beyond the learning environment.
- *Context meaningful to domain and learner:* The learning activities should engage learners on practical aspects of the learning domain.
- *Scaffolded activities:* The system design should include learner activities that help learners to comprehend the knowledge acquired from the learning content.
- *Elicit learner understanding:* There should be appropriate feedback to enable learners to understand the content.
- *Formative evaluation:* To enhance the performance of learners, there is a need for constructive feedback from the system in a process of formative evaluation.

4.3.4 The heuristics of Karoulis and Pombortsis

Finally, in this section on early heuristics and guidelines, it is noted that Karoulis and Pombortsis (2003) present heuristics regarding the following:

- The system's capability to support active interaction between learners and educators.
- The system's support for the development of learners' problem-solving methods.
- Availability of tools to support different learning levels of different learners.
- Capability of the environment to allow experimentation with the knowledge that the learners have acquired.
- Different representations and solutions that can be explored by learners.
- Appropriate feedback within the system to address the needs of learners with different learning styles.

- Features that enable learners to assess their learning activities.

4.4 Synthesis of evaluation criteria for e-learning applications

Various factors influence the results of usability evaluation. For example, the results may be influenced by the participants, the test objectives, the task design, the usability criteria applied, and the skills of the evaluator (Chisnell, 2009; Lindgaard & Chattratichart, 2007; Perfetti, 2010).

The rest of this chapter presents two frameworks of evaluation criteria synthesised by the present researcher. Criteria are also called heuristics and the terms are used interchangeably. The framework in this section, Section 4.4, integrates a variety of criteria – classic ones and current ones – that are appropriate for evaluating different forms and methodologies of e-learning, including tutorials such as the target system evaluated in this study. There is also a need to integrate learning outcomes into the usability evaluation criteria of learning systems to determine how the system supports or impedes learning (Carter, 2007).

Not all criteria are suitable for evaluating all types of systems. The section that follows Section 4.4, namely Section 4.5, concentrates on criteria that are particularly appropriate for stand-alone interactive tutorials. These criteria are used as a foundation for the empirical part of this research, namely, the evaluation of *Instap!E4B* by means of a questionnaire survey and usability testing sessions. The empirical studies are described in Chapter 7.

A number of approaches have been used to categorise heuristics for e-learning (Albion, 1999; Squires, 1999; Ssemugabi & De Villiers 2010). This study bases its main categories of criteria on categorisations by Nielsen (1994b), Albion (1999), Ssemugabi and De Villiers (2010) and by other researchers. The sub-criteria within the main categories are obtained by combining heuristics of various researchers and synthesising them into a framework for usability evaluation of educational systems. They are grouped into three main categories: general interface design, content-related, and learner-centred instructional design heuristics, presented in Tables 4.1, 4.2, and 4.3, respectively. After each sub-criterion, the sources are cited that influenced the present researcher in generating that criterion.

4.4.1 General interface design heuristics

The general interface design heuristics are essentially derived from Nielsen's heuristics (Albion, 1999; Nielsen, 1994b). Nielsen's heuristics were enhanced and customised by Squires and Preece (1999) to become heuristics focused on learning systems. Furthermore, the categories are influenced by recent work of Ssemugabi and De Villiers (2010), Spratt and Lajbcygier (2009), Greenwald (2011), and various other authors, who are cited in Table 4.1.

Table 4.1: General interface design heuristics

General interface design heuristics (based on Nielsen (1994b))		
	Criterion	**References**
1	**Visibility of system status**	
	• The system should keep the user/learner informed about what is going on through constructive, appropriate and timely feedback.	Dix *et al*. (2004); Nielsen (1994b); Spratt and Lajbcygier (2009); Squires and Preece (1999); Ssemugabi and De Villiers (2010).
	• The system should have built-in feedback mechanisms that respond to learners' answers in learning situations and exercises.	Dickinson (2012); Dix *et al*. (2004); Greenwald (2011); Spratt and Lajbcygier (2009); Ssemugabi and De Villiers (2010).
	• Regular updates should be made available to ensure currency of the content.	Dix *et al*. (2004); Shank (2012); Squires and Preece (1999).
	• For every learner-initiated action, there should be a visual or audio response by the system so that learners can understand the consequences of their actions.	Squires and Preece (1999); Ssemugabi and De Villiers (2010).

2	**Match between the system and the real world, that is, match between designer and learner models** • The metaphor usage should correspond to real-world objects or concepts. Learning applications should be developed in such a way that authentic real-world issues are addressed.	Dix *et al*. (2004); Forman (2011); Nielsen (1994b); Squires and Preece (1999).
	• Language used in the system for terms, phrases, symbols, and concepts, should be similar to those known by the learners in their everyday environment.	Albion (1999); Dix *et al*. (2004); Greenwald (2011); Nielsen (1994b); Sharma and Mishr (2007); Squires and Preece (1999).
	• The information in an application should be arranged in a natural and logical order.	Dix *et al*. (2004); Nielsen (1994b); Squires and Preece (1999); Ssemugabi and De Villiers (2010).
	• Sound, graphics and video that may distract users and impede achievement of learning objectives, should be avoided.	Dix *et al*. (2004); Nielsen (1994b); Squires and Preece (1999).
3	**User control and freedom** • Users (in this case, learners) should be able to control the system.	Dix *et al*. (2004); Greenwald (2011); Nielsen (1994b); Squires and Preece (1999).
	• There should be clear exit paths to enable learners to move away from erroneous situations. This can be strengthened by ‘undo’ and ‘redo’ facilities.	Dix *et al*. (2004); Greenwald (2011); Squires and Preece (1999); Ssemugabi and De Villiers (2010).
4	**Consistency and adherence to standards** • There should be common operating system standards throughout the system.	Alessi and Trollip (2001); Forman (2011); Greenwald (2011).
	• The use of concepts, words, situations, and actions should be standardised to refer consistently to the same meaning throughout a system.	Dix *et al*. (2004); Squires and Preece (1999).
	• Systems should be standardised to avoid misinterpretation by users from different geographical locations.	Shi and Clemensen (2008).
5	**Error prevention, specifically prevention of peripheral usability-related errors** • An e-learning system should have a ‘guarding’ mechanism to minimise possibilities of serious errors in addition to procedures for fixing errors.	Dix *et al*. (2004); Forman (2011); Greenwald (2011).
6	**Recognition rather than recall** • There should be visibility of instructions, options, objects to be manipulated, and actions to be taken.	Dawson (2010); Dix *et al*. (2004); Greenwald (2011); Squires and Preece (1999).

	• The user should easily recognise a systems' dialogue without referring to the previous ones.	Dawson (2010); Dix *et al*. (2004); Ssemugabi and De Villiers (2010).
7	**Flexibility and efficiency of use** • The system should address the needs of different users ranging from novice to expert. • Shortcuts that are not visible to novice users should be provided to help frequent users to increase their interaction pace and task completion. • Systems should be flexible to support alternative navigation paths and to allow learners to adjust settings.	Dix *et al*. (2004); Squires and Preece (1999); Ssemugabi and De Villiers (2010). Dix *et al*. (2004); Squires and Preece (1999). Squires and Preece (1999).
8	**Aesthetics and minimalism in design** • Content that is likely to distract the users/learners during a session, should be avoided in the system.	Dix *et al*. (2004); Nielsen (1994b); Squires and Preece (1999).
9	**Recognition, diagnosis, and recovery from errors** • To enhance recovery from errors, error messages should appear in simple understandable language. • Error messages should identify the problem and guide the learners towards recovery. Recovery should involve minimal typing. • The system should have 'undo' and 'redo' buttons to enable the users to make recoveries from errors.	Dix *et al*. (2004); Squires and Preece (1999). Dix *et al*. (2004); Squires and Preece (1999); Ssemugabi and De Villiers (2010). Dix *et al* (2004); Squires and Preece (1999).
10	**Help and documentation** • The Help facility and related information should be easily accessible by learners. They should guide a learner in a systematically manner to task completion.	Bernsen and Dybkjaer (2009); Dix *et al*. (2004); Squires and Preece (1999); Ssemugabi and De Villiers (2010).

4.4.2 Content-related heuristics

Heuristics related to the learning content assist educators in evaluating the subject matter in the context of meeting the intended learning objectives (Albion, 1999). Albion and other authors are cited after each sub-criterion in Table 4.2.

Table 4.2: Content-related heuristics

Content-related heuristics (based on Albion (1999))		
	Criterion	**References**
1	**Relevance of reference materials** • Content and its packaging should be relevant to the learning scenarios and at a level appropriate to the learners.	Albion (1999); Aroyo and Dicheva (2004); Masemola and De Villiers (2006); Zaharias (2006).
2	**Assistance supportive rather than prescriptive** • Contextual help should support the learners to locate relevant resources without limiting their scope.	Albion (1999); Dickinson (2012); Perfetti (2010); Shelley (2001); Zaharias (2006).
3	**Materials engaging** • The presentation style and content of the e-learning system should engage learners and encourage them to work through a learning session.	Albion (1999); Holzinger (2008); Quinn (1996); Vrasidas (2004); Zaharias (2006).

4.4.3 Learner-centred instructional design heuristics

The third category is based on learning theories and instructional design models as presented by different authors, who are cited after the sub-criteria. They emphasise learner-centricity and are relevant as guidelines for evaluating e-learning systems.

Table 4.3: Learner-centred instructional design heuristics

Learner-centred instructional design heuristics (based on Albion (1999))		
	Criterion	**References**
1	**Clarity of goals, objectives and outcomes** • There should be clear and communicable learning goals throughout the learning sessions, supported by measurable learning outcomes.	Albion (1999); Alessi and Trollip (2001); Holzinger (2008); Northrup (2007); Perfetti (2010); Spratt and Lajbcygier (2009).
	• The learning goals and objectives should be clear in every part of a learning session.	Alessi and Trollip (2001); Reeves and Reeves (1997).

2	**Collaborative learning** • Negotiation and interaction should support construction of knowledge by the learners. • Educators should act as facilitators, coaches, mentors, guides or partners with learners, but not controllers of learning.	Reeves and Reeves (1997); Vrasidas (2004). Alessi and Trollip (2001); De Villiers (2003).
3	**Appropriateness of the level of learner control** • In an e-learning application, learners need significant freedom to control the pace of their learning. This freedom to have some control of learning content and pace gives learners a sense of ownership of the learning process. • Depending on the intended goals, learners should take the initiative for the preferred learning methods, time, place, content, and sequence.	De Villiers (2003); Khan (2002); Shelley, (2001); Squires (1999). De Villiers (2003).
4	**Support for personally significant approaches to learning** • An e-learning system should enable learners to use the learned skills beyond the learning environment. • An e-learning system should be capable of being used together with other instructional media to support learning. • Before learners use a system independently, they should be oriented to the necessary concepts. Background familiarisation can be obtained by relevant tasks. • Existing skills and prior knowledge should be incorporated into the new content.	Albion (1999). Squires and Preece (1999). Squires and Preece (1999). De Villiers (2003); Squires and Preece (1999).
5	**Cognitive error recognition, diagnosis and recovery** • Learners learn from their mistakes and thus the learning environment should include some situations that can challenge them into constructing solutions. • There should be adequate help that can guide learners and help them recover from cognitive errors. • An educational system should give learners the opportunity to come up with their own way of addressing challenges encountered during learning sessions.	Squires and Preece (1999). Squires and Preece (1999); Ssemugabi and De Villiers (2010). Oliver (2000).
6	**Feedback, guidance and assessment** • The system should allow for feedback that serves the purpose of regular communication between the learners and educators, and amongst the learners.	Albion (1999); Northrup (2007); Squires (1997); Vrasidas (2004).

	• The system should guide learners through appropriate questions/exercises/activities and provide them with answers/feedback geared towards achieving the intended learning objectives. • Feedback should focus on improving learners' performance.	Alessi and Trollip (2001). Albion (1999); Squires and Preece (1999);Vrasidas (2004).
7	**Context meaningful to domain and learner** • The learning activities should be engaging and interesting to learners. • Presentation of knowledge should be in a way that is appropriate to the context. • Symbols, icons and names should help learners to relate the learning context to the real world.	Albion (1999); Vrasidas (2004). Jonassen (1994); Squires (1999). Reeves and Reeves (1997).
8	**Learner motivation, creativity and active learning** • The target users should be motivated by the learning system. • The system should promote creativity on the part of learners by including innovative motivational features. • The application should engage learners by providing attractive content and interaction, but without causing distractions. • A learning system should support active learning whereby learners analyse and/or classify content, and make deductions.	De Villiers (2003); Reeves and Reeves (1997); Squires (1997); Vrasidas (2004). De Villiers (2003); Vrasidas (2004). Vrasidas (2004). Alessi and Trollip (2001).

4.5 Framework of evaluation criteria for this study

In the context of an e-learning tutorial as discussed in Chapters 2 and 3, the heuristics should support attainment of the learning objectives as well as the usability of the system. Table 4.4 in this section presents a framework of proposed criteria that are suitable for usability evaluation of stand-alone e-learning tutorials and that will be the basis for developing the research instruments of this study, namely the questionnaire survey and the tasks for the usability testing sessions. Tables 4.1, 4.2 and 4.3 in the previous section presented criteria/heuristics in three main categories that are relevant to the evaluation of a variety of e-learning applications. The framework presented in this section has extracted criteria from these three tables that are particularly suitable for evaluating tutorials and added some others. The origin of each in Section 4.4 is acknowledged. For instance, Criterion 1 in Table 4.4 in this section has a citation indicating that it is based on Table 4.3, Criterion 1.

Albion's (1999) study is mainly about learners' needs, and therefore his content-related heuristics are important and contribute to the questionnaire and usability tasks generated for the present study.

Table 4.4: Framework of criteria applied in this study

	Framework of criteria applied in this study	
	Criterion	**References**
1	**Clear learning goals, objectives and outcomes** [Table 4.3 (1)]	
	1.1 An e-learning tutorial should have clear and well-communicated learning goals that a learner is to achieve upon completion of a session.	Albion (1999); Alessi and Trollip (2001); Holzinger (2008); Northrup (2007); Perfetti (2010); Spratt and Lajbcygier (2009).
	1.2 The learning goals and objectives should be clearly evident throughout a learning session.	Alessi and Trollip (2001); Reeves and Reeves (1997).
2	**Presentation of domain in a meaningful and engaging way** [Table 4.2 (3); Table 4.3 (7)]	
	2.1 The tutorial and its content should engage learners with practical activities that are interesting and engaging.	Albion (1999); Holzinger (2008); Quinn (1996); Vrasidas (2004); Zaharias (2006).
	2.2 Knowledge should be presented in a way that is appropriate to the learning context.	Jonassen (1994); Shelley, (2001); Squires (1999).
	2.3 There should be a match between the symbols, icons and names used and the learning context in the real world.	Reeves and Reeves (1997); Dix *et al*. (2004).

3	**Nature of the learning activities** [Table 4.3 (8)]	
	3.1 There should be activities that support learners in comprehending the new knowledge acquired.	Albion (1999); Shelley (2001); Ssemugabi and De Villiers (2010).
	3.2 The system should support active learning in which learners analyse content, and make deductions.	Alessi and Trollip (2001).
	3.3 The learning system should motivate the target users.	Reeves and Reeves (1997); Squires (1997); Vrasidas (2004).
	3.4 The system should promote learners' creativity by including innovative features.	De Villiers (2003); Vrasidas (2004).
	3.5 Learners should be engaged through attractive content and interaction. This should however avoid causing distractions during learning sessions.	Vrasidas (2004).
4	**Elicit learner understanding** [Table 4.2 (2); Table 4.3 (4)]	
	4.1 Help should be available to support learners in understanding the learning content and locating what they need.	Albion (1999); Dickinson (2012); Perfetti (2010); Shelley (2001); Zaharias (2006).
	4.2 New learning content should incorporate existing skills and learners' prior knowledge.	De Villiers (2003); Squires and Preece (1999).
5	**Feedback for formative evaluation** [Table 4.3 (6)]	
	5.1 Formative evaluation is important in supporting learning and communicating with learners. The system should provide constructive feedback as part of formative evaluation.	Albion (1999); Northrup (2007); Squires (1997); Vrasidas (2004).
	5.2 Feedback should focus on improving learners' performance and increasing their confidence in learning.	Albion (1999); Squires and Preece (1999); Vrasidas (2004).
	5.3 The tutorial should guide learners through appropriate questions, exercises and/or activities, and provide responses/feedback aligned to the intended learning objectives.	Alessi and Trollip (2001).

6	**Support for skills transfer to the real world** [Table 4.1 (2)] 6.1 The learning system should enable transfer of learnt skills to the learners' real world, where they can apply the skills in their everyday activities.	 Albion (1999); Dix *et al*. (2004); Greenwald (2011); Nielsen (1994b); Sharma and Mishr (2007); Squires and Preece (1999).
7	**System status should be visible** [Table 4.1 (1)] 7.1 The system should keep the user/learner informed about what is going on. 7.2 An e-learning tutorial should have built-in feedback mechanisms to respond to learners' answers to learning activities and exercises. 7.3 Every learner-initiated action should have a corresponding visual or audio response by the system so that learners can understand the consequences of their actions.	 Dix *et al*. (2004); Nielsen (1994b); Spratt and Lajbcygier (2009); Squires and Preece (1999). Dickinson (2012); Dix *et al*. (2004); Greenwald (2011); Spratt and Lajbcygier (2009); Ssemugabi and De Villiers (2010). Squires and Preece (1999); Ssemugabi and De Villiers (2010).
8	**Appropriate learner control** [Table 4.3 (3)] 8.1 Learners need freedom to control the pace of their learning. This gives them a sense of ownership of their learning process. 8.2 Learners should take the initiative for the preferred learning methods, time, place, content (i.e. unit or section), and sequence. This, however, depends on the learning objectives.	 De Villiers (2003); Khan (2002); Shelley, (2001); Squires (1999). De Villiers (2003).
9	**Cognitive error recognition, diagnosis and recovery** [Table 4.3 (5)] 9.1 Since learners learn from their mistakes, the learning environment should include some complex situations that require them to construct solutions. 9.2 The system should provide adequate help to guide learners and help them recover from cognitive errors. 9.3 An e-learning system should permit learners to be innovative in	 Squires and Preece (1999). Squires and Preece (1999); Ssemugabi and De Villiers (2010).

	addressing challenges encountered during learning sessions.	Oliver (2000).
10	**Active learning and learner motivation** [Table 4.3 (8)] 10.1 The system should engage its learners through suitable content.	 Vrasidas (2004).
11	**System's flexibility, efficiency and navigation** [Table 4.1 (7)] 11.1 The system should be flexible to the needs of different users, for example novices, intermediate users and experts. 11.2 There should be shortcuts that are not visible to novice users but that are visible to frequent users, so as to increase their paces of interaction and task completion. 11.3 Learners should be able to adjust settings to suit their needs.	 Dix *et al*. (2004); Squires and Preece (1999); Ssemugabi and De Villiers (2010). Dix *et al*. (2004); Squires and Preece (1999). Squires and Preece (1999).
12	**Help facility** [Table 4.1 (10)] 12.1 Learners should easily be able to access a Help facility. There should be simple and systematic guides to assist learners.	 Bernsen and Dybkjaer (2009); Dix *et al*. (2004); Squires and Preece (1999); Ssemugabi and De Villiers (2010).

4.6 Summary and conclusion

This chapter answers the first Research Question of this study: *What are appropriate criteria for evaluating an e-learning tutorial?* The goal of this chapter was to set up a comprehensive framework of criteria for usability evaluation of an e-learning system, more specifically a stand-alone e-learning tutorial.

Section 4.3 discussed initial heuristics and concepts for evaluating educational software, dating back a decade or more. The heuristics presented in Section 4.4 are important as a basis for criteria and principles for evaluating e-learning environments in general, and can be applied in a variety of evaluation methods, including usability testing and user surveys which are used in this study. Three categories of heuristics were synthesised from the literature: general interface design, content related, and learner-centred instructional design heuristics.

A set of criteria extracted from Section 4.4 was presented in Section 4.5 as being particularly suitable for evaluating interactive tutorials such as *Instap!E4B*. They address usability factors and pedagogical requirements, and will be used to develop this study's research instruments for evaluating *Instap!E4B* by means of usability testing and a questionnaire survey. Table 4.4 is the resulting framework of criteria specifically for use in the two evaluation studies. They will be converted to evaluation statements for the questionnaire survey and will be used in designing usability metrics for the usability testing in the laboratory.

This chapter has considered criteria for the evaluation of e-learning applications in general and stand-alone e-learning tutorials in particular. Any usability evaluation requires evaluation criteria and evaluation methods. The frameworks synthesized in this chapter provide appropriate *evaluation criteria*, while Chapter 6 will present the overall research design, and focus on how two specific *evaluation methods* were applied in evaluating the target application, *Instap!E4B*. The next chapter, Chapter 5, discusses the structure, functionality and facilities of *Instap!E4B* as an interactive tutorial.

Chapter 5: The target application: *Instap!E4B*

5.1 Introduction

The design of interactive e-learning tutorials involves considerable background investigation to understand the target group of learners and the requirements for the intended learning. Regarding hardware, the application should be platform-independent. And, from a pedagogic viewpoint, the tutorial functionality should guide learners through its interfaces and learning content (Harrison, 2010). Finally, such a system should support the user in understanding its different features and capabilities (Korhonen, 2010) so that they can be used effectively and efficiently.

The CD-based e-learning software application that is evaluated in a case study, is *Instap!E4B*. ‘*Instap’* is a Dutch word, of which the translation is *board (embark). Instap!E4B* is part of the '*MULTITAAL*' (*many languages*) series, developed by a computing technologists and language experts to support the learning of a variety of languages. As the name indicates, this application is used by learners to learn the use of the English language for business purposes. This chapter discusses the structure, functionality and facilities of *Instap!E4B*, and how it is used for learning. The information contextualises the case study and provides a background to the evaluations discussed in Chapter 7, thus outlining the situation in which Research Question 2 is answered.

In Section 5.2 factors are considered that underlie the structure of interactive tutorials in general. Section 5.3 describes, in particular, the different interfaces of this system, while Section 5.4 briefly explains the Help facility of *Instap!E4B*.

5.2 Factors underlying interactive tutorials

There are a number of factors that underlie the requirements of an interactive electronic tutorial. In particular, this section relates to stand-alone tutorials such as the CD-based target application, *Instap!E4B*. Offline applications delivered on CDs are popular in e-learning, because they do not require Internet connectivity. This makes it easier for learners in remote areas without Internet infrastructure to be able to learn.

Technology should be applied in e-learning to increase the visibility of the learning content (Vrasidas, 2004). Khan (2002) observes that technology has served to facilitate learner-centred e-learning. CD-based applications, as a form of offline e-learning, are frequently based on behavioural psychology and learning theory, where the learning content resembles programmed textbooks and instructions, as explained by Alessi and Trollip (2001). E-learning tutorials such as *Instap!E4B* can be used to complement traditional classroom learning (Zhang, Zhao, Zhou & Nunamaker, 2004).

Learners, educators and technology influence the features and objectives of e-learning tutorials. The subsections that follow discuss these factors.

5.2.1 Learners

In any educational environment, learner-centred design (LCD) is very important. Good LCD can support learners in using the environment and achieving the learning objectives. As discussed in Chapter 3, learners have different needs, depending on their prior knowledge and backgrounds. Regardless of the technology used, an application should suitably deliver the content to the learners in such a way that the technology is transparent. When learners struggle to understand and use their technology, it is likely to impede the learning processes.

5.2.2 Educators

The educators play the important role of guiding learners towards achieving learning objectives. It is therefore important that educators, as well as technologists, make input into the design of learning systems. Subject-matter experts are best placed to advise on how the learning content should be presented. Additionally, they should be consulted when systems are re-engineered or updated to maintain their currency.

5.2.3 Development technology and expertise

The technology for developing e-learning applications should not be studied to the isolation of other factors (Vrasidas, 2004). In any e-learning development, technologies should be selected that are appropriate for the content, context and instructional methods (Vrasidas & Glass, 2002). According to De Villers (2005), technology in e-learning should merely be the medium and not the message itself. Barton (2004) stresses the importance of using tools that support usability and enhance the human-computer interaction. The designer should also pay careful attention to the format and structure of the academic content.

5.3 The structure of *Instap!E4B*

5.3.1 Introduction to *Instap!E4B*

Instap!E4B originated as part of Project *MULTITAAL* (‘many languages’) at North West University in South Africa, under the leadership of Prof. Dr Lut Baten. *Instap!E4B* is an instance of a generic system, in which the same underlying software logic is populated with language-specific content to support the learning of different languages. With South Africa’s multilingual reality, there was a need for educational software on indigenous languages. For beginners, there were the tutorials; Tsenang! (Setswana), Ngenani! (Isizulu) and *Sondelani!* (Isixhosa). There was also *Instap!Nederlands* (Dutch) and *Dag!sê* (basic Afrikaans). On a post-intermediate level there was *Instap!Afrikaans* and *InStap!E4B* (Business English). *Instap!E4B* was used with kind permission from the designer-developer, Prof. Dr Lut Baten. The authorisation is in Appendix A-I.

Instap!E4B, also known as *Instap!Business English,* has a graphical user interface (GUI) that presents the learning sessions and assesses learners on learnt content. As in any interactive tutorial, a short familiarisation session and exploration of the system is important for new users. This accustoms them to its interfaces and indicates what content is offered. The sections that follow, describe the screens and how their interactions assist in learning English for use in the context of business.

This tutorial runs on a Microsoft Windows operating system. It does not require a great deal of memory and can be used on different types of workstations.

The next subsections introduce the different screens of the *Instap!E4B* system.

5.3.2 Home page for *Instap!E4B*

The home page can be accessed by double-clicking on the *Instap!E4B* icon on the desktop or from the Start menu. The home page consists of three main regions: the support toolbar at the top, the chapter overview section in the middle and the learning session’s toolbar at the bottom.

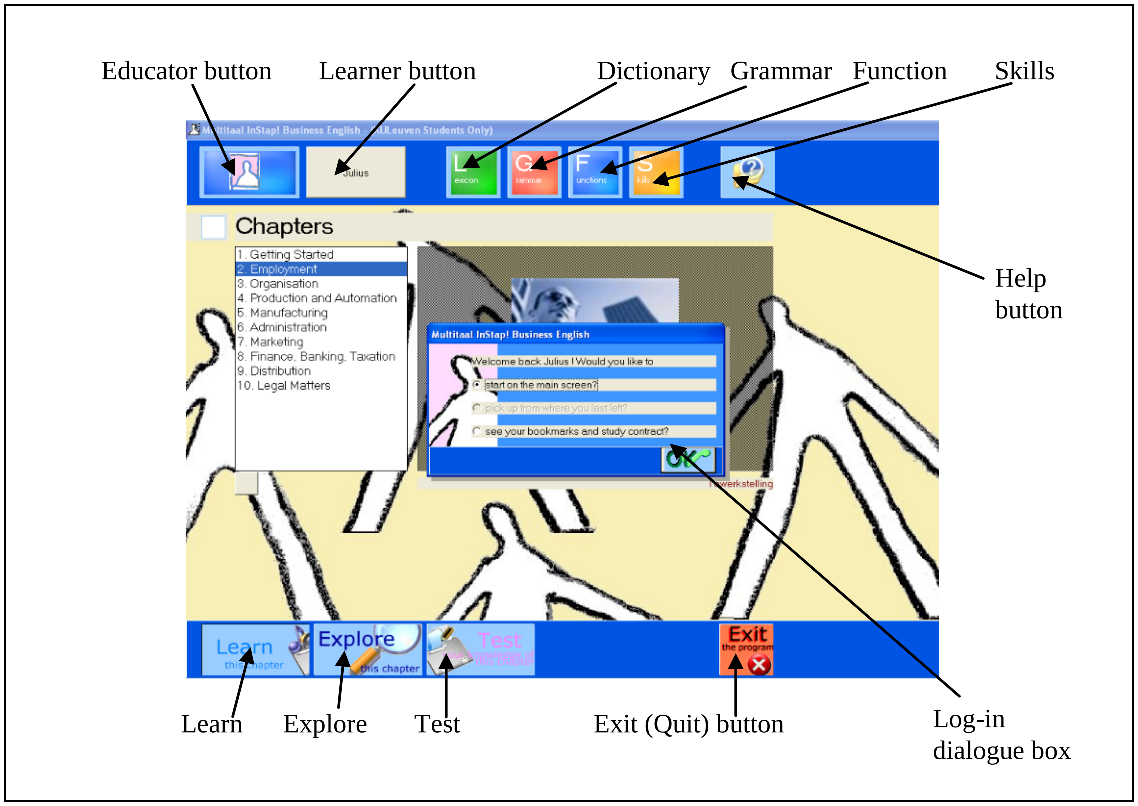

Figure 5.1: Home page containing logging-in dialogue box

5.3.2.1 Support toolbar

At the very top, as indicated in Figure 5.1, is the support toolbar that is consistently available on all the screens that are opened later. The toolbar presents icons that link learners to specific pages in the system. These buttons are briefly described:

- The first button (*Educator* button) on the toolbar is the educator's help link. It informs educators about the developers of the system and offers a 10-minute tour of the environment.

- The next button (*Learner* button) is for options and bookmarks. It supports learner control by allowing learners to open the previously bookmarked sessions via a direct link. The learners can also perform their own system setting by providing, for example, their own name and preferred language. This link also enables learners to select the required study transactions, be it introduction, extensive coaching or any other available option.

- The third button on the toolbar is for *Dictionary* (called *Lexicon*) that a learner can use in a similar manner to a hardcopy dictionary.

- The *Grammar* button is used to learn grammatical skills that are necessary in Business English.

- The selection of the *Functions* button will elaborate the ways in which different words are used in Business English.

- There is also a button called *Skills* that presents certain necessary skills for Business English. These skills include writing, spelling and presentation.

- The icon at the top right corner is the online *Help* for this system. It provides essential help to learners during learning sessions. It takes the format of the help facilities found in most systems, thus making it familiar and easy to use. It has sections for content, index and printing of the help content.

These buttons are further discussed in Section 5.3.4, with Section 5.3.4.7 dealing with online Help facility.

5.3.2.2 Chapter overview section

The central region of the screen provides an overview of the chapter. It is from this part that a learner can select the intended chapter for a learning session. In Figure 5.1, there is a listing under *Chapters* about different topics that are relevant to learning Business English. The *Chapters* have varying content based on different fields and professions. This is important since learners with varying interests may need to learn Business English.

5.3.2.3 Learning sessions toolbar

The third region at the bottom of the screen has three buttons, *Learn*, *Explore*, and *Test*, shown in Figure 5.1. They support a learner in exploration of a lesson, a target chapter or in attempting a test. The *Learn* button is used to access the learning content for concepts such as grammatical use of words and situations in which they can be used. The *Explore* button is used when a user requires a sense of what the system offers within its tutorial functionality. The *Test* button is used when learners are ready to practise the learnt content through an exercise or a test.

5.3.3 Learning session

To access a learning session (a chapter's content), select a chapter by clicking from the list box with the header *Chapters*. This is followed by clicking on the *Learn* button at the bottom left corner of the screen as seen in Figure 5.1. The three buttons that appear at the bottom of the screen in Figure 5.1 are used in a learning session.
As explained in Section 5.3.2.3, they are:

- Learn
- Explore
- Tests

The system does not dictate a fixed sequence to be followed during a learning session. One learner may choose to start from the *Explore* section, while another learner may choose *Test* to have a self-assessment of prior skills.

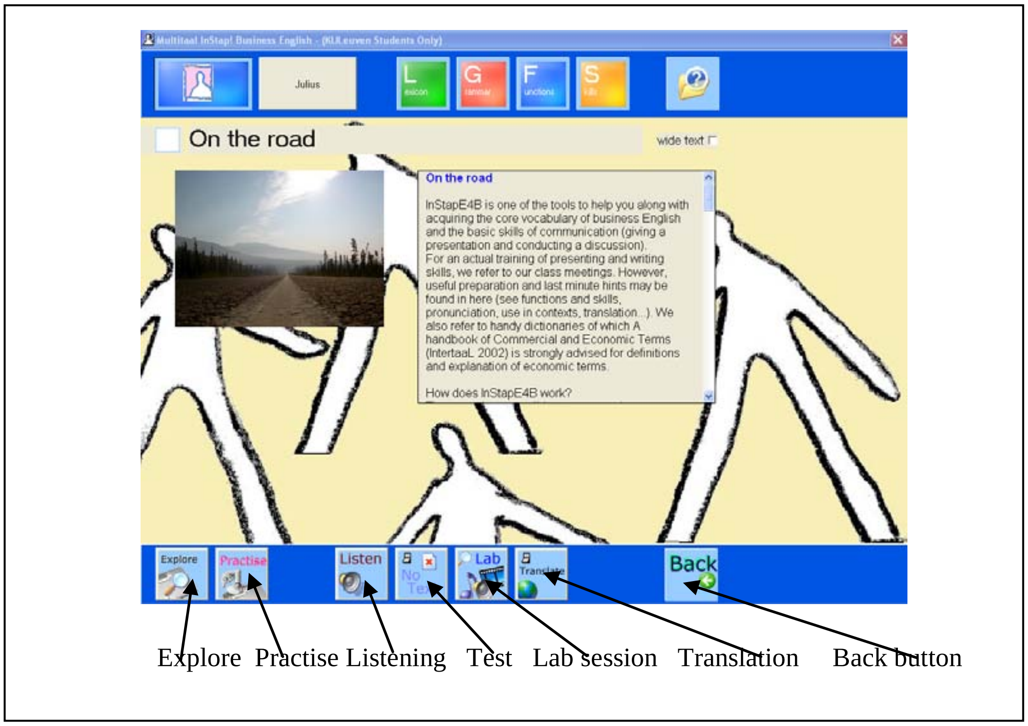

Figure 5.2: Home page (ready for learning sessions)

Figure 5.2 shows a screen used during a learning session. The buttons at the bottom show available interfaces for exploring, listening and translating, among others. This screen is obtained by clicking on the *Learn* button as shown in Figure 5.1.

The next subsection briefly describes a typical learning session.

5.3.3.1 Parts of Learning session

Learning sessions are accessed from *Learn* and *Explore* buttons in Figures 5.1. On clicking the *Explore* button in Figure 5.1, the screen shown in Figure 5.3 opens. From that screen a learning session can deal with vocabulary, grammar, situations and skills in using Business English.

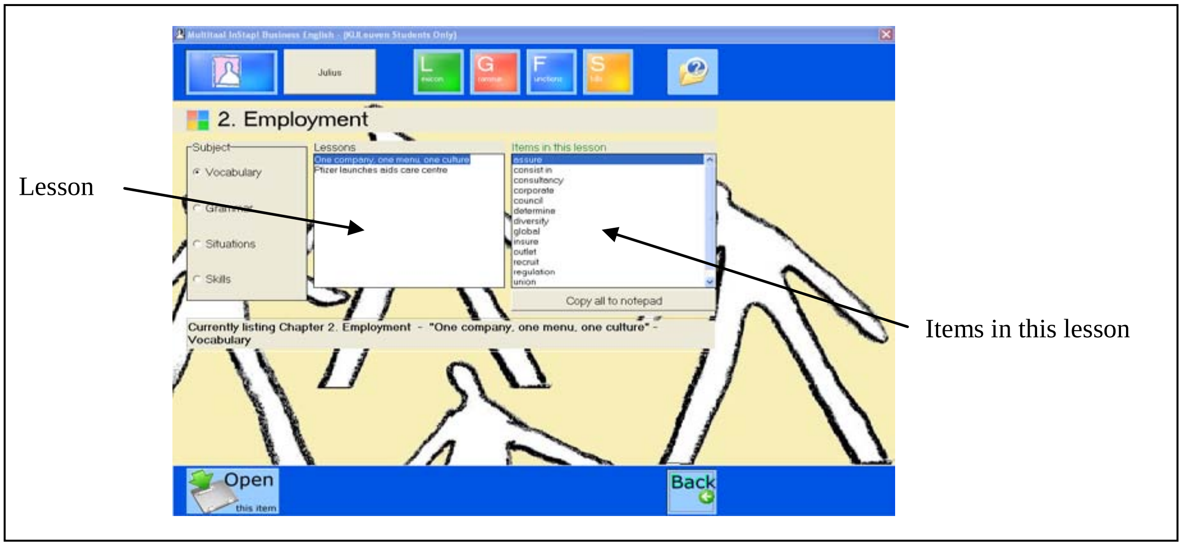

Figure 5.3: First page of a learning session

(Obtained by selecting *Learn* and *Explore* buttons)

On selecting a word from the list box for *items in this lesson*, a learner can click on the *Open* button at the bottom left corner of the screen that will lead to the screen shown in Figure 5.4. It will give an explanation of the selected word in use. Note the dialogue screen that opened as an overlay. The screen also offers a *Back* button for learners to review the previous screen.

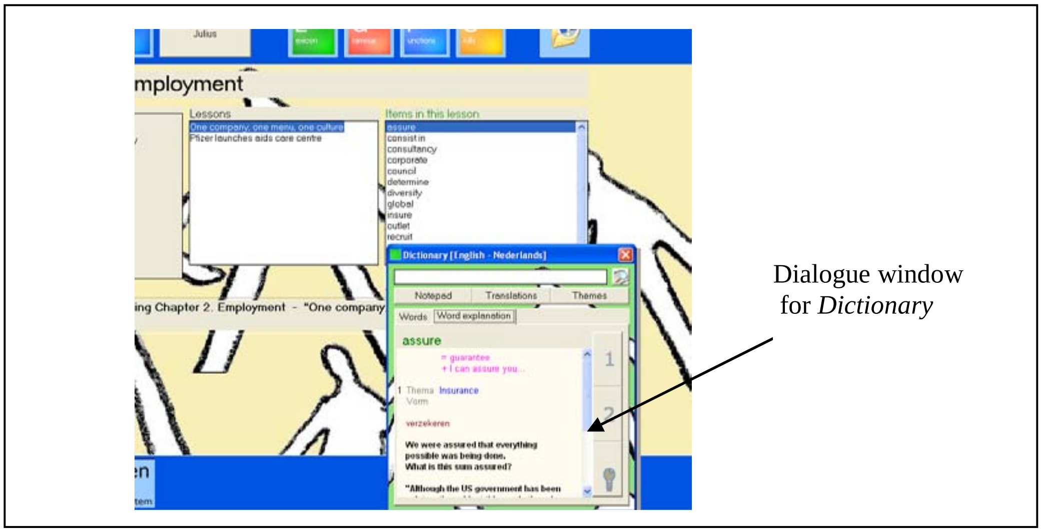

Figure 5.4: Learning session page (for learning vocabularies)

(Obtained by selecting a word to learn, then selecting *Open*)

The system offers a variety of exercises including multiple-choice questions, *Click* exercises, and *Fill-in* exercises. The exercises are called *Test*.

Figure 5.5 depicts a typical example for testing a chapter of learning.

5.3.3.2 Exercise/Test session

The exercise sessions can be accessed using two methods:

- Click on *Test* button on screen shown in Figure 5.1, or
- Click on *Practise* button on screen shown in Figure 5.2.

Figure 5.5 shows a screen for a testing session for the different skills learnt. To start a test using this screen, a learner should:

- Select the test subject, for example, *Grammar* from the left side of the screen.
- From the screen that is obtained (*Exercise* screen), click the *Do* button at the bottom left corner.

A learner has the option of attempting an exercise as a timed one (done within a pre-set duration) or not timed. This is done by selecting the check box called ‘against time’ on the right hand side of screen.

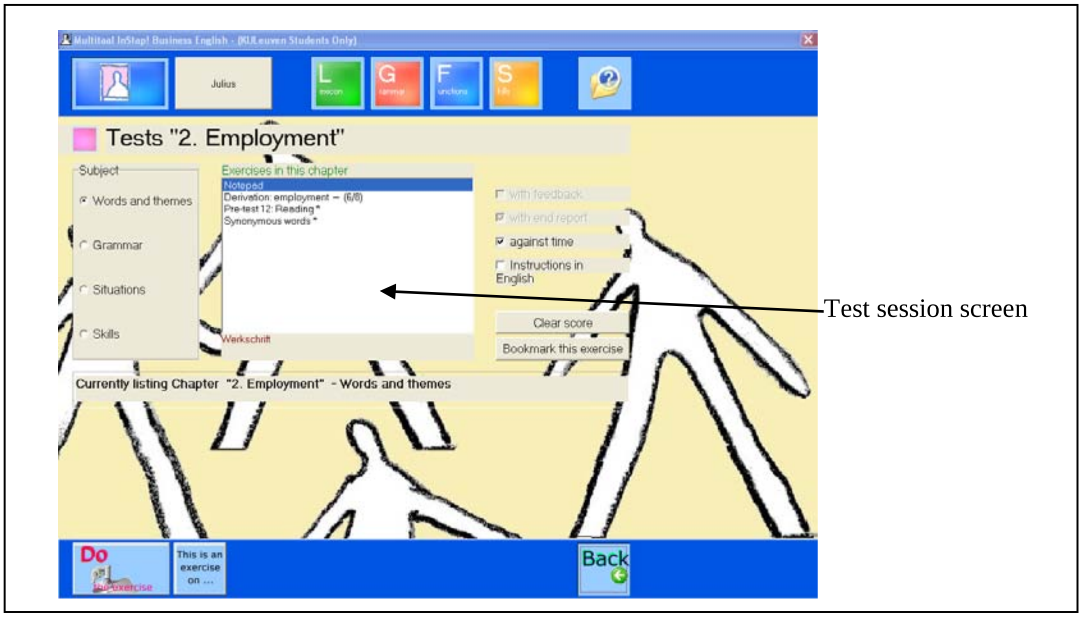

Figure 5.5: Testing session page

(Obtained by selecting the subject, for example, *Grammar* then *Do* button)

During a test session, the user selects an answer and clicks on the selected response before moving to the next question. Figure 5.6 shows a screen for a test session in progress. The *Correction* button is used to give feedback about the expected answer (i.e. the correct answer) for the attempted question.

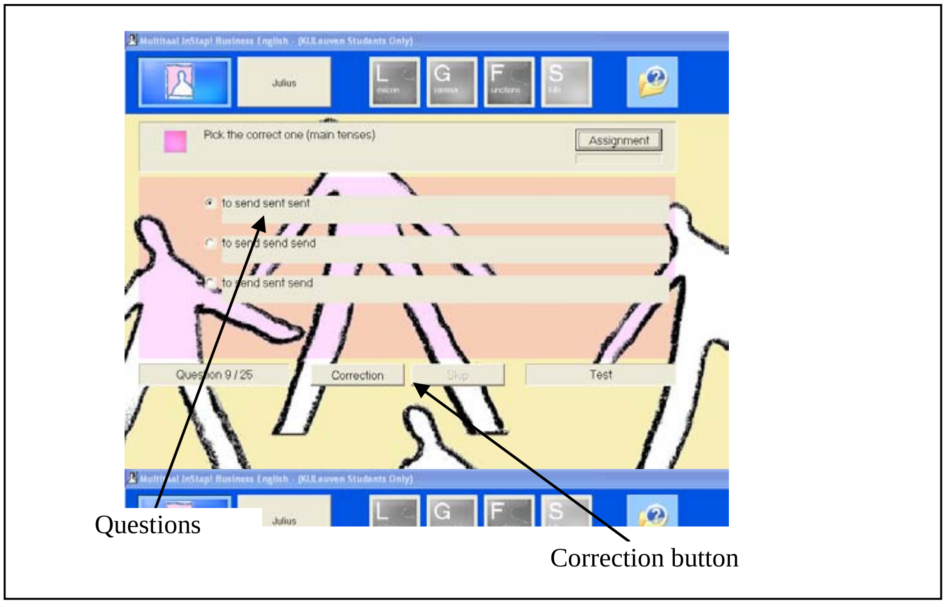

Figure 5.6: Testing session page (with test in progress)

At the end of a test session the system reports the scores as shown in Figure 5.7.

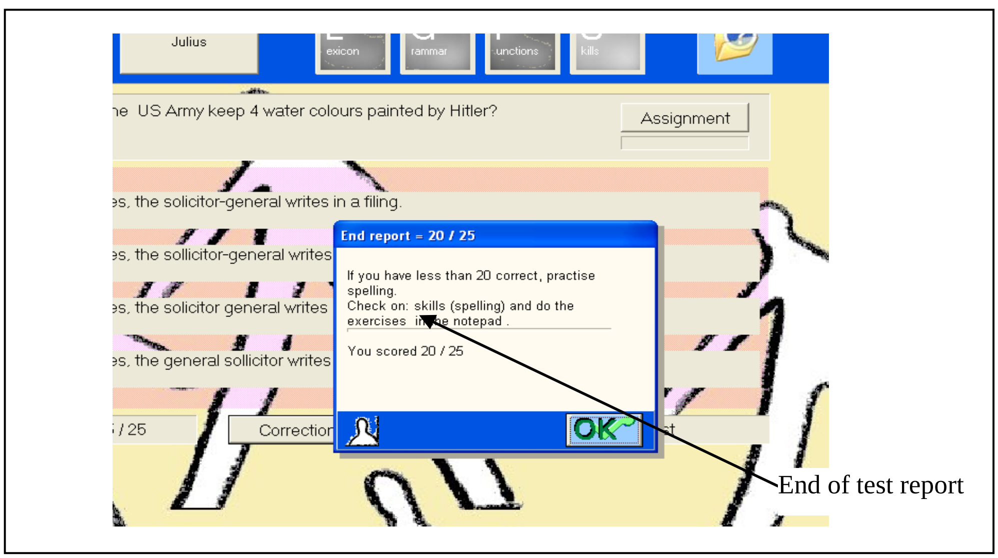

Figure 5.7: Report page (at end of testing session)

The report includes recommendations regarding what the learner should practise in the case of an unsatisfactory score. Note the report appearing as an overlay on the dialogue window in Figure 5.7.

5.3.4 System interfaces supporting learning

Various support buttons take a user directly to an interface intended for that kind of user. The support buttons appear as icons on the toolbar at the bottom of Figure 5.2 in Section 5.3.3.

This section now discusses these interfaces, which were introduced in Section 5.3.2.1

5.3.4.1 Teacher's (educator's) help

As explained earlier, this *Educator* facility provides online help to the educators. It gives contact information for the developers of the system, background information about the need for such systems to aid learners of Business English, and a tour of what is offered on the CD-based tutorial.

5.3.4.2 Learner control interfaces

The system provides the learners with an interface called *Learner* that they can use for learner control. It is the second icon on the top row (toolbar) in Figure 5.2 and can be used to customise settings that would help in their personal learning. It is that point where a learner can view the lessons that have been bookmarked. Bookmarked lessons have double asterisks after the title. The *Bookmark* tab displays a record of sessions that learners had started but stopped them to continue later. Therefore on resumption such learners do not need to start from the beginning.

Figure 5.8 shows the screen for learner control.

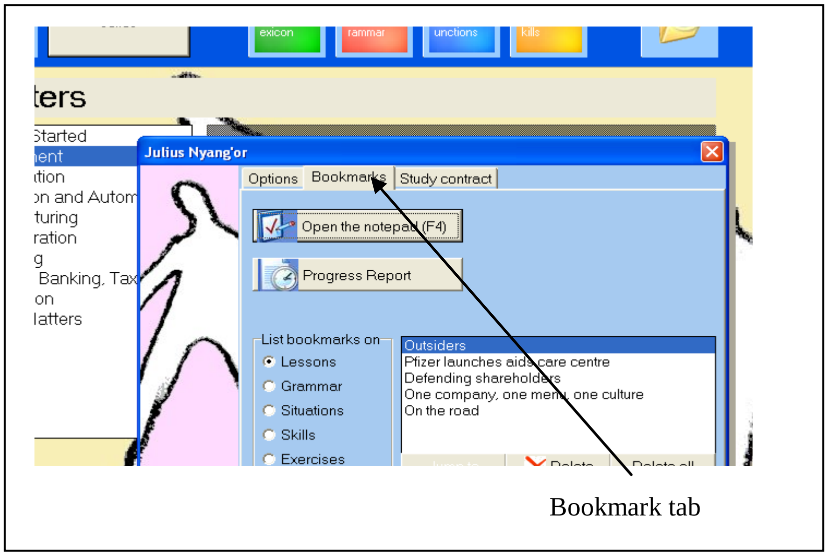

Figure 5.8: Learner control page showing bookmarking tab

Learners can place bookmarks at different points in the system. Having bookmarked an item, it can be accessed through the *Options* and *Bookmarks* and *Study contract* buttons in the toolbar in Figure 5.8. Additionally, this learner control interface has an option in the form of a tab for setting a *Study contract*. A study contract informs a learner about the lessons, grammar, communicative situations and skills that should be completed within a given period.

- This is set up by clicking the *Study contract* tab.
- Click *Contract proposals* button and sign up to the preferred contract.
- Close the window and restart *Instap!E4B*.

Triple asterisks will appear against each item that appears in the contract. The bookmarked items can also be accessed from the contract.

5.3.4.3 Dictionary

In learning any language with the use of technology, a dictionary is vital and should be available in the system. The *Instap!E4B* dictionary is represented by the green button (named *Lexicon*) on the toolbar as seen on Figure 5.6. It provides learners with explanations of words that they do not understand. On clicking the button, users obtain a dialogue window with two tabs, one for the words and the other one for explanations. Search facilities are available for words.

5.3.4.4 Grammar

The *Grammar* button (see Figure 5.6) enables learners to learn different grammatical aspects of Business English. A learner needs to make a selection, via its interface windows, then the system guides a learner regarding the use of the word. The purpose of the *Grammar* functionality is to help learners master skills to make it easier to use the acquired knowledge in the future. The screen for *Grammar* is shown in Figure 5.9 which demonstrates a case where a learner selected '*–able* or *–ible'* from the *List* tab. Via the *Item* tab, the system gave examples of the usage.

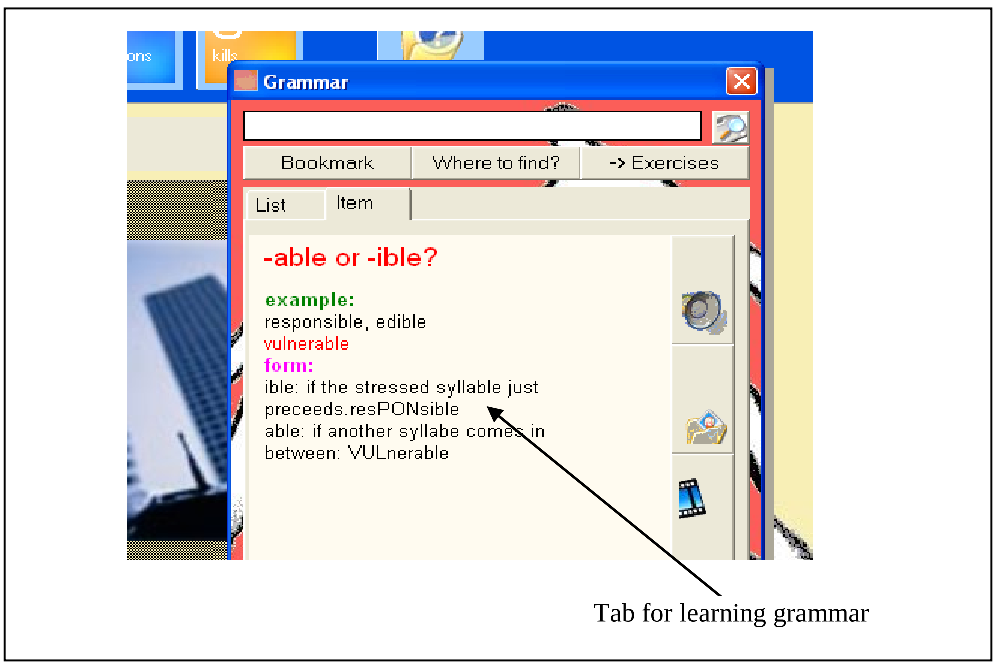

Figure 5.9: Grammar page

5.3.4.5 Functions

The *Situations and Functions* interface shown in Figure 5.10, assist in the learning of various contexts where words and phrases can be used in Business English. A learner selects a particular word and is given different options for its use.

In Figure 5.10, the selected word is ‘dinner’. The system provides elaborations and gives examples of situations in which ‘dinner’ is used in Business English.

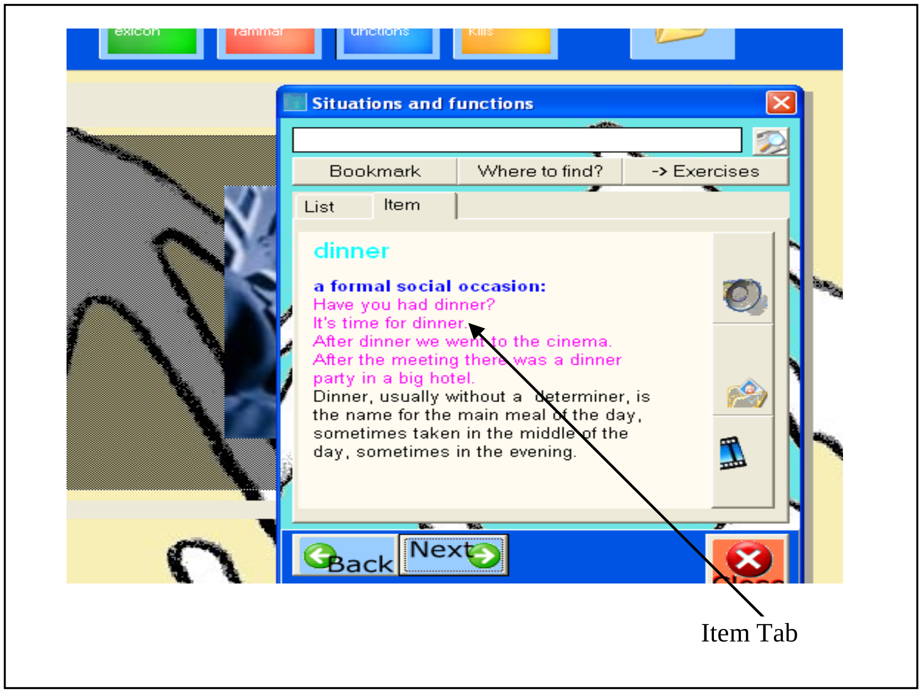

Figure 5.10: Situation and functions page (showing use of a word)

Via the *Item* tab, the learner is shown the meaning of the word and how it can be used. *Instap!E4B* is a multi-modal system and there is also the option of listening to an audio version, which is obtained by clicking the speaker icon on the right hand side of that screen (see Figure 5.10).

5.3.4.6 Skills

Instap!E4B also facilitates the learning of different skills, for example, writing a letter. Figure 5.11 shows a screen that lists the particular *Skills* a learner can acquire during a learning session. A learner can select any of the listed skills and obtain the corresponding format via the *Item* tab.

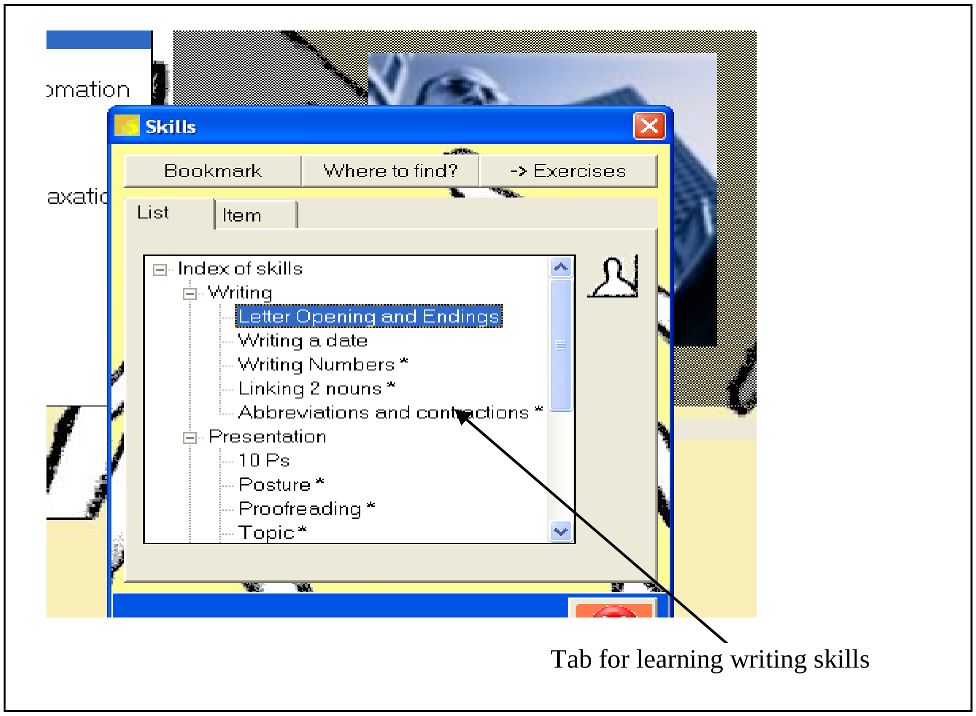

Figure 5.11: A session for learning skills for Business English

5.3.4.7 Online Help facility

In any tutorial, whether CD-based or web-based, the help facility is important in supporting the activities provided in a learning session. Correctly designed online help facilities can assist the learners in using the tutorial without difficulty. To provide flexibility, a system should provide more than one way of accessing online help. In the *Instap!E4B*, the online help is available in two forms:

- Help that appears when the mouse is pointed at an icon.
- Built-in (online) help.

Use of these two forms of Help is now described:

Help via the mouse pointer

Figure 5.12 shows the type of help that becomes available upon pointing the mouse at an icon or button such as, in this case, the *Practise* button. It is a concise, yet informative overlay.

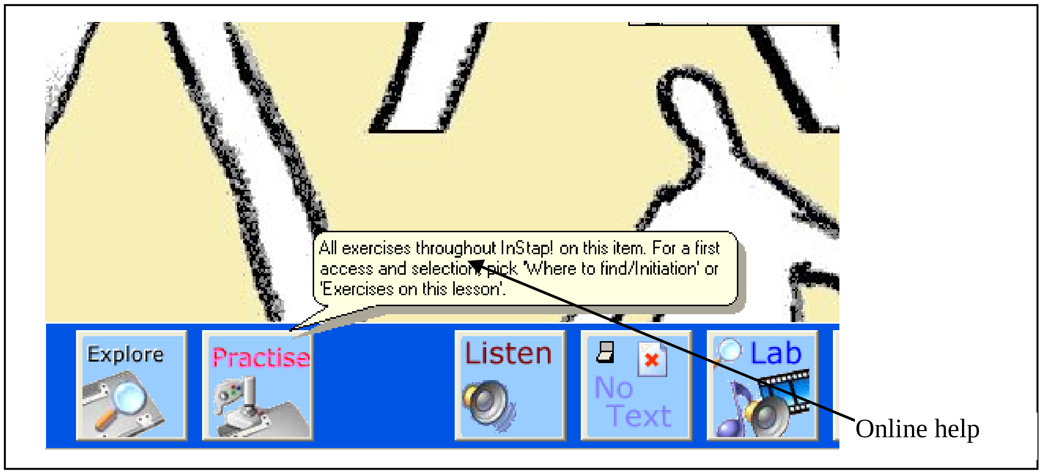

Figure 5.12: Page showing Help that appears on pointing at an icon

Built-in (online) Help facility

This Help facility is detailed and supports learners on system use during actual learning sessions. It is available upon logging-on and throughout usage sessions. Figure 5.13 shows a screen from this Help facility, whereby a learner is assisted through a session on lesson exploration. The dialogue window for online help opens on top of the main screen to ensure that the learning session is continuous. This is important for flexibility.

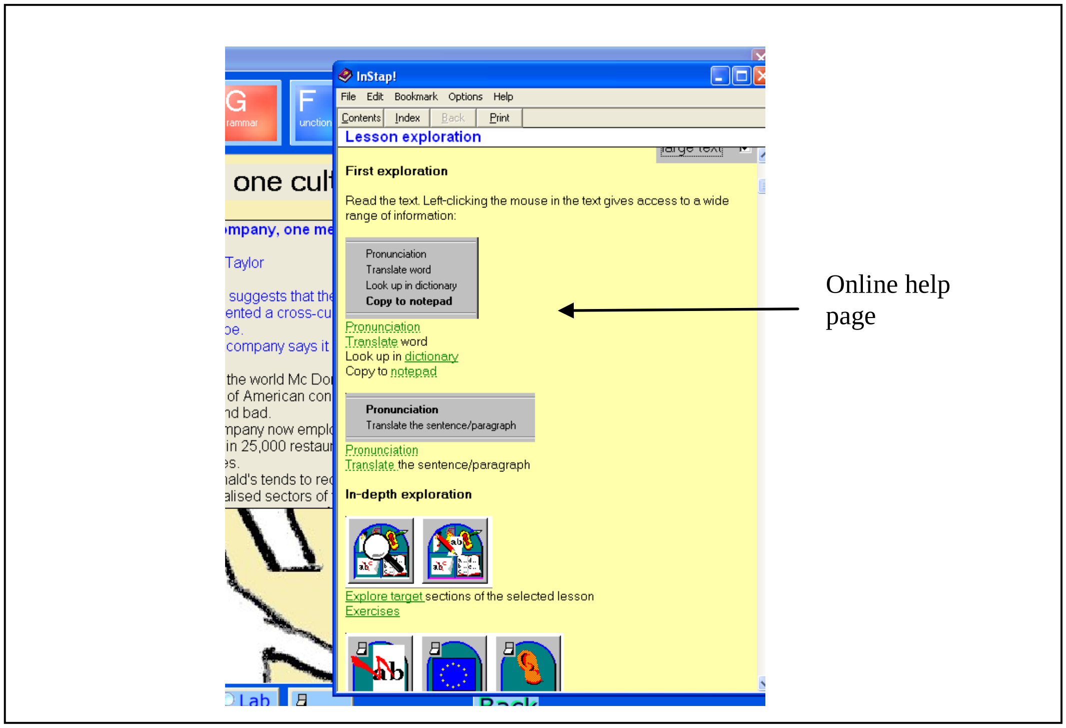

Figure 5.13: Built-in (online) Help facility for the system

5.4 *Instap!E4B* view from the perspective of the literature

5. 4.1 *Instap!E4B* as an e-learning tutorial

Instap!E4B is an e-learning tutorial, since it complies with the features of an e-learning tutorial as described by Alessi and Trollip (2001). These features are presented in Section 2.4.2. *Instap!E4B* has presentation segments in its 'chapters' (Figure 5.1) whereby learning content is presented for learners to read, and thereafter followed by activities segments and tests to test the learners' understanding of the content (Figure 5.5). Learner control allows users to choose what they do next, in a sequence of their own choice. However, very little feedback and remediation is available.

5. 4.2 *Instap!E4B* as a multimedia

The design of *Instap!E4B* makes it a multimedia presentation, since it has feature such as images, text and sound interface for presentation of content. This complies with features of multimedia systems as described in Section 2.4.11. It does not use diagrams and animations to illustrate concepts, but this is understandable, because it teaches language and not subjects like science.

5. 4.3 Underlying learning theory

Instap!E4B is an interactive tutorial that is designed based mainly on principles of behavioural psychology (Alessi & Trollip 2001; De Villiers, 2005) as discussed in Section 2.2.1. It approaches learning in the form of presentation of knowledge and exercises to learners, who are recipients. Learners are tested on their knowledge and not on their reasoning, but this is an appropriate way of teaching and learning the subject matter.

5.5 Summary and conclusion

It was important to contextualise the case study in this research by introducing the structure and approach of the target application, *Instap!E4B*, which was designed to facilitate e-learning of Business English. The descriptions showed various situations in which this tutorial can be used during learning sessions and exercises, and explained the associated help facilities.

The system's architecture includes key interfaces and functionality that are important for learning via tutorials, namely presentation of information for learning, opportunities for practising, and testing. The system also allows the learners to use both reading and listening as means of learning. The chapter has given insight into the features and functionality of the *Instap!E4B* environment. It follows appropriately after the literature study of Chapter 2, showing how concepts can be practically implemented. It also serves as a background for the empirical evaluation studies discussed in Chapter 7.

Following the presentation of evaluation criteria in Chapter 4 and the contextualised discussion in this chapter, the next chapter, namely Chapter 6, focuses on the research design and methodology used in this masters' degree study. It sets out the methods used for the collection and analysis of data, with a view to answering the research questions and describing the approaches used for reporting results.

Chapter 6: Research design and methodology

6.1 Introduction

The primary goal of this study, as mentioned in Section 1.3, is to investigate the impact of using two usability evaluation methods (UEMs) to assess the usability of e-learning tutorials and to identify usability problems. The study also establishes the effectiveness of using two UEMs in combination instead of only one. The two UEMs being applied are usability testing in a controlled environment and a user questionnaire survey. The target system is *Instap!E4B*, an interactive CD-based tutorial for learning Business English. This chapter overviews the overall design and methodology used in the study. This is important in ensuring that there is a structured approach towards answering the Research Questions.

Section 6.2 discusses the research design. Section 6.3 revisits the research questions and indicates where they have been answered in the study. This is followed by descriptions of the two research methods. In Section 6.4, the technique of evaluating by a user survey is explained, while Section 6.5 describes the usability testing methodology used in this study. The approaches to be used for data analysis and for the reporting of results are covered in Section 6.6. The chapter concludes with a summary in Section 6.7.

6.2 Research design

According to Mouton (2008), a research design is an outline of how one intends to carry out a study that is guided by certain research questions. This approach is used in this study using the Research Questions in Section 1.4.

This study takes the form of a mixed-method research design that involves quantitative and qualitative methods (Creswell, 2009; Creswell & Plano-Clark, 2007; Doyle, Brady & Byrne, 2009). It is a combination of survey research and controlled observation of participants (Merriam, 2002; Mouton, 2008) done in the context of a case study, which can be defined as an investigation intending to answer particular research questions that draw a range of different evidence from the case scenario (Gillham, 2000a). Olivier (2009) explains that a case study is intended to get a considerable amount of information regarding one (or a few) member. In the former situation, it is a called a single-case design. This research uses a single-case design, where the case is *Instap!E4B*, an e-learning tutorial that supports the learning of Business English by learners who have post-secondary school qualifications. As stated, case studies normally require multiple forms of evidence and can provide qualitative and/or quantitative data (Olivier, 2009). In the present study, as in other case studies, a real-world situation is it investigated. Usability evaluation is conducted via two different evaluation methods and the findings are compared. The study applies triangulation (Gillham, 2000a), as post-usability-testing questionnaires and qualitative observation of the usability testing sessions, are used alongside the main data collection methods of gathering quantitative usability metrics and administering a learner survey.

Figure 6.1 presents the activities to be followed in this study. As shown in the figure, the study uses an empirical research design to investigate the usability of *Instap!E4B* and to identify usability problems and positive aspects of the application. This is done by conducting controlled user testing sessions in which participants undertake specified tasks and by administering a user-based survey. The data collection techniques applied are therefore:

- Observation and recording during usability testing, and
- Administration of questionnaires during the user survey.

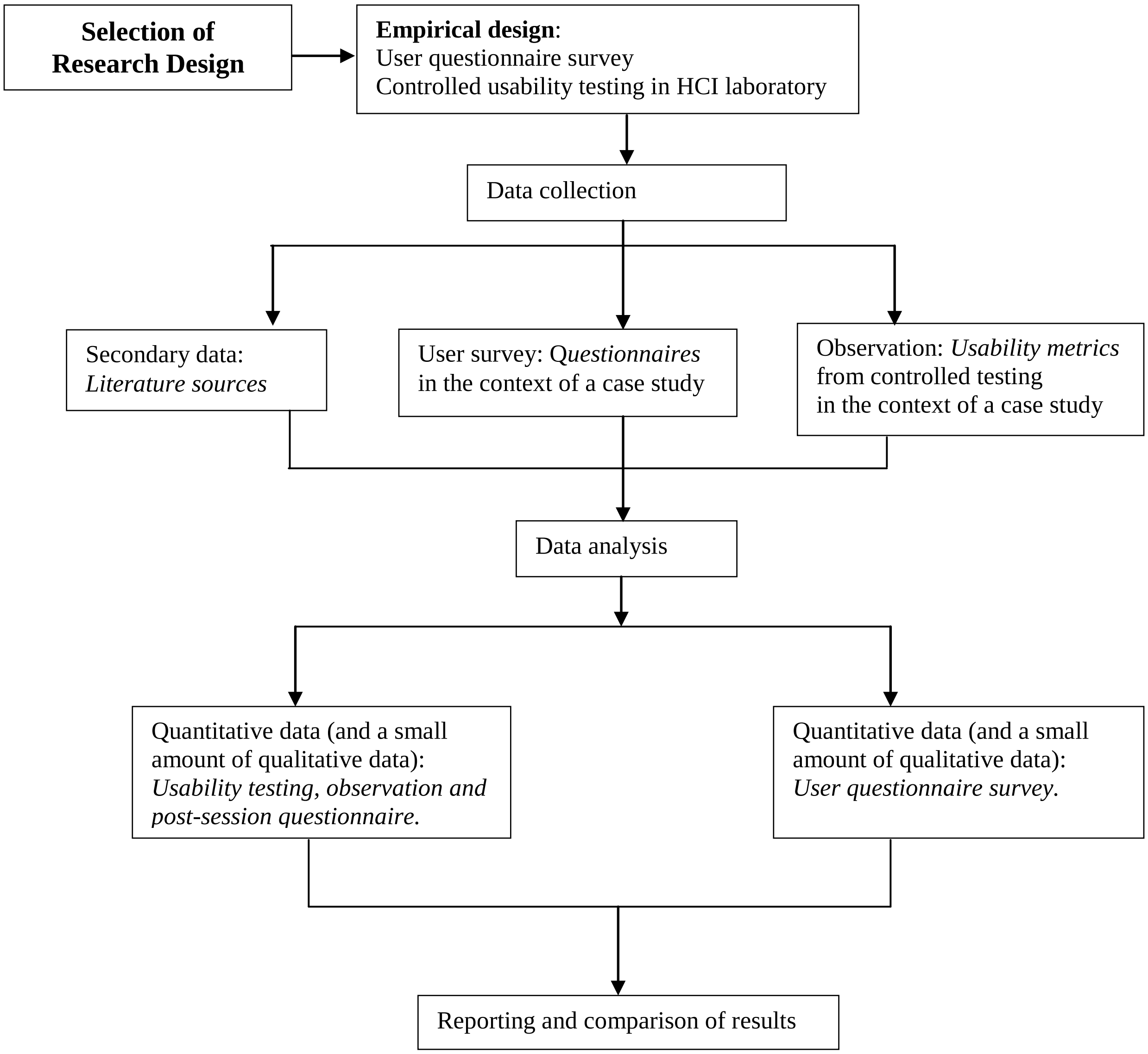

Figure 6.1: The research design

The two are supplemented by analysis of literature sources, using the literature as secondary data. The collected data was both qualitative and quantitative.

This study focuses on usability in the particular context of usability evaluation of educational software. The goal is to use the two usability evaluation methods to identify usability problems in *Instap!E4B* and compare the findings. The synergistic use of two different UEMs supports the process of answering the research questions.

To undertake an evaluation, a researcher needs both research methods and evaluation criteria. Mixed-methods studies are strengthened by the use of more than one data collection technique. The selection of a set of appropriate evaluation criteria is a study in itself and, for this research, the synthesis of criteria has been presented in Chapter 4. The first research question (see Section 6.3) served as a guideline to the generation of evaluation criteria. These criteria, in turn, will result in

- sets of exploratory questions and evaluation statements for the questionnaire, and
- tasks and usability metrics for user testing.

The criteria thus determine the content of the questionnaire and help in identifying usability testing tasks.

6.3 Research questions

Table 6.1 presents the research questions and shows how they are addressed within the study. This is done by indicating the sections where they have been answered.

Table 6.1: Research questions in the design

Research Question number	Research questions	Answered in Section
1	**What are appropriate criteria for evaluating of an e-learning tutorial?**	4.4 4.5
2	**What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?** • What usability and learning problems in *Instap!E4B* can be identified from evaluation by a user questionnaire survey? • What usability and learning problems in *Instap!E4B* can be identified from evaluation by usability testing?	7.2 7.3 7.4
3	**How effective is the use of more than one evaluation method to identify learning and usability problems in an interactive CD-based e-learning tutorial?** • How do the results and the findings of the two usability evaluation methods (UEMs) compare? • Does the dual approach to evaluation enrich the findings? • Do the findings contribute to meta-evaluative knowledge in the context of usability evaluation of e-learning?	7.5

From Table 6.1 above, it is evident that most of the research questions are answered in Chapter 7. Question 1 is answered in Chapter 4 that presented the evaluation criteria for this study.

6.4 User questionnaire survey methodology

The survey instrument, in the form of a questionnaire, was administered to a selected sample typical of the user population. In order to enhance reliability of the results, this group of participants was fairly large, namely 50 participants.

Using Section 4.5 and Table 4.4 with the evaluation criteria to be applied in this study, the questionnaire was designed to collect both qualitative and quantitative information (Bernsen & Dybkjaer, 2009; Mouton, 2008; Olivier, 2009). A section of the questionnaire towards the end had open-ended questions, which were intended to gain qualitative information (Mertens, 1998). However, most participants did not complete these sections for qualitative data. Those who did answer them, made comments that repeated their responses to Likert-scale questions. The little qualitative data that was collected, was therefore integrated into the quantitative data.

The following phases, discussed in the ensuing subsections, guided the process of the user survey:

- Designing of questionnaire (Section 6.4.1)
- Preparation of the user questionnaire survey (Section 6.4.2)
- Selection of participants (Section 6.4.3)
- Conducting the pilot survey (Section 6.4.4)
- Conducting the main survey (Section 6.4.5)

6.4.1 Designing the questionnaire

The intended outcome of this phase was a comprehensive questionnaire (Gillham, 2000b; Bernsen & Dybkjaer, 2009). Concepts encountered in the literature study guided and directed the design of the questionnaire instrument, which had as its main purpose the investigation of usability aspects of *Instap!E4B* and, in particular, the identification of problems users experienced in using the application.

Firstly, primary demographic information and experience about the participants was captured as recommended by Grant, Malloy and Murphy (2009). Statements were grouped according to various aspects under investigation, namely: interface design, system interaction, learner-centred instructional design, and the system's navigation and control. Responses were based on a five-point Likert rating scale ranging from *strongly agree* to *strongly disagree*.

6.4.2 Preparation of the user survey

Unlike usability testing, the user survey was not conducted in a controlled environment. The participants completed the questionnaire at a time and place of their own choice. They were provided with a CD-ROM that had the software (*Instap!E4B*) installed on to a computer. Adequate measures were in place for technical support, for example, configuration and installation, so as not to impede the intended objectives of the study. The survey occurred only after the system was installed in the participants' environments and confirmed to be operating satisfactorily.

6.4.3 Selection of the participants

The research exercised care in selection of participants. It was important that those selected would continue through to the conclusion by participating in the user questionnaire survey. Consideration was also given to the age and nature of the participants in order to ensure the validity of the collected data (Mertens, 1998; Quesenbery, 2008). For both the pilot and the main questionnaire survey, heterogeneous samples of participants were used. They were representative with regard to demographic groupings, namely, gender and age group. The participants were aged between 18 and 60 years, being an age range of likely users. It was also a requirement that they were computer literate and technologically literate. The participants were mostly employees and students in tertiary learning institutions. The selection of participants was purposive with emphasis being put on balancing the numbers in terms of gender.

6.4.4 Pilot user survey

The process of piloting a questionnaire is intended to test and review it using a small sample of stereotypical users prior to the main survey (Bernsen & Dybkjaer, 2009; Shneiderman & Plaisant, 2005). As earlier mentioned in Section 6.4.3, piloting a study assists in reducing inadequacies within the instrument (Olivier. 2009), which in this case is a questionnaire. There were eleven participants for the pilot survey. For logistical reasons, the respondents were all from Kenya, where the researcher was based.

6.4.5 Main user survey

The main questionnaire survey was based on the pilot questionnaire. Following the pilot study, certain questions were refined to clarify them and enhance the appropriateness of the survey. Fifty-seven (57) questionnaires were distributed. A total of 50 participants completed the questionnaire, that is a response rate of 88%. The participants were persons mainly known to the researcher and thus it was not difficult to liase with them regarding participation. They all gave verbal consent. Most of them were excited by the fact that the information was being used for academic / research purposes. Moreover, they felt proud to have been selected as participants and it gave them a sense of how research is conducted. Because all the participants met the requirement of being computer literate, they were not given time to practise using the system. Most of the participants (46) had access to computers at their locations and completed their questionnaires individually. For the 11 participants who did not have access to computers, the researcher made arrangements for them to access computers at convenient times. They thereafter completed the questionnaires individually. Eight participants returned their completed questionnaires within two days. The rest took up to three weeks because they were committed with other daily activities of their lives.

6.5 Usability testing methodology

Usability testing as a UEM, as discussed in Section 3.4, is an effective method of determining the usability of a software application and particularly of finding problems that users experience in using the system (Barnum, 2002; Chisnell, 2009). Usability testing (UT) involves using the sophisticated technology in the controlled environment of an HCI laboratory to conduct in-depth monitoring and recording of users' interaction with software and to identify problems in the system. The process usually entails taking measurements based on a set of criteria referred to as usability metrics and, as such, it provides quantitative data from the controlled environment of the evaluation. However, it is also used to collect qualitative data through techniques such as 'think aloud' whereby users speak as they perform tasks. Qualitative data can also be obtained via interviews or short questionnaires after the testing sessions. Testing is usually carried out on a small sample of the real users (Mouton, 2008; Olivier, 2009; Perfetti, 2010). Nielsen (1994a) recommends using 3 to 5 participants in order to collect sufficient data, but Hwang and Salvendy (2010) advocate 8-12.

The UT approach involves the participants going through a session involving a baseline test, performance tasks, and end-of-session survey (Bernsen & Dybkjaer, 2009; Sperry & Fernandez, 2008). The planning process should address the following main activities (Barnum, 2002; Barnum, 2008; Perfetti, 2010; Sperry & Fernandez, 2008), which are discussed respectively in the sections in brackets:

- Identification of tasks and metrics (Section 6.5.1).
- Preparation and procedure for usability testing (Section 6.5.2).
- Conducting the pilot study (Section 6.5.3).
- Conducting the main study (Section 6.5.4).

6.5.1 Identification of usability testing tasks and metrics

The tasks prescribed for the testing sessions in this study (listed in Appendix A-IV) were based on a scenario similar to what day-to-day learners would encounter while using the system. Caution was exercised to ensure that the task list was not too long, which could cause participants to lose the requisite concentration. It was anticipated that the combined tasks would take about 30 to 45 minutes for each participant to complete. Each task consisted of various subtasks.

Immediately after the usability testing sessions, participants were required to answer certain questions, so as to ascertain their subjective opinions about the target system. This set of questions is also referred to as a paper survey (Sperry & Fernandez, 2008). Most of the questions had multiple response options, but a few were open-ended. All the information that was provided by the participants was confidential and only used for the purposes indicated in the consent form (Appendix A-II).

The following usability metrics, extracted from Section 3.4, were used during usability testing (Bernsen & Dybkjaer, 2009; Dix *et al*., 2004; Preece *et al*., 2007; Stone *et al*., 2005):

- Time taken to complete tasks (minutes).
- Number of commands used (using mouse clicks).
- Number of times stuck (user errors).
- Number of error messages.
- Recovery time from errors (minutes).
- Number of assisted recoveries.
- Number of unassisted recoveries.
- Number of times accessing Help facility.

6.5.2 Preparation and procedure for usability testing sessions

6.5.2.1 Preparation for usability testing

The equipment for the evaluation sessions was tested for accuracy before commencement of the sessions. Informed consent forms were provided to obtain formal permission of the participants. The following guidelines as presented by Barnum (2008) were taken into account during the sessions:

- Maintenance of privacy in the testing room.
- The facilitator to do double duty by taking notes, as well as recording the sessions for later re-viewing and analysis.
- Creation of a simple test plan that identifies what is to be tested, who is to be tested, and the number of tests to be carried out.
- A testing process that establishes consistency in the script and the methodology in each test session.
- The computer and overall set-up for test participants to be similar to the normal situation during an e-learning session.
- Availability of video and audio equipment to record the session for future review of the results.

The pilot testing sessions and the main usability tests at UNISA's HCI laboratory were based on several defined tasks, with each addressing specific objectives. The pilot usability testing is briefly discussed in detail in Chapter 7, Section 7.3.1

6.5.2.2 Procedure for usability testing of Instap!E4B

The testing was conducted with a selected sample of stereotypical learners who were briefed about the evaluation process. The procedure below was followed during the sessions, in line with standard approaches (Barnum, 2002; Chisnell, 2009).

- Welcoming remarks to the participant(s).
- Informing the participants about the purpose and intentions of usability testing.

- Briefing participants by demonstrating and explaining the equipment for the usability evaluation session.
- Informing participants what the tasks involve.
- Requesting participants to voluntarily complete and sign consent forms (available in Appendix A-II).
- Providing the list of tasks for the usability tests.
- Debriefing the participant upon completion of a session.

Following each test, about ten minutes were spent setting up the equipment to check and confirm its readiness before the start of the next testing session.

6.5.3 Usability testing: Pilot study

A pilot study helps to minimise inadequacies within the study instrument (Olivier, 2009) and provides an opportunity for adjustment before the main study. The researcher came to Pretoria from his hometown in western region of Kenya for testing sessions. The pilot usability testing sessions were conducted over two days at the usability laboratory, on the Muckleneuk Campus of the University of South Africa (UNISA) in June 2009. Four participants were acquired from staff of the School of Computing at UNISA. Although these participants were not actual users of the *Instap!E4B* e-learning software, they were typical of the type of users with regard to their ages and occupations. Table 6.2 gives the profiles.

Table 6.2: Profiles of the participants in the pilot usability testing study

	Profession / Occupation	Age (years)	Level of education	Computer use	Computer experience (years)
Participant 1	Academic staff	24-30	Undergraduate	Expert user	Over 5
Participant 2	Support/Administration	24-30	Diploma	Expert user	Over 5
Participant 3	Support/Administration	35-40	Diploma	Expert user	Over 5
Participant 4	Support/Administration	35-40	Postgraduate	Expert user	Over 5

6.5.4 Usability testing: Main study

As with the pilot study, the main usability testing sessions were conducted in the usability laboratory at UNISA's Muckleneuk Campus. The researcher visited UNISA for 10 days in October 2011 and the duration of the usability testing was 3 days, during which the researcher and a laboratory facilitator worked with twelve participants drawn from staff/students of UNISA. Although these participants were not actual users of the *Instap!E4B* e-learning software, they are typical of the type of users with regard to their ages and occupations. Table 6.3 gives the profiles of the participants for the main study.

Debriefing

The debriefing session mentioned in the procedure list, took place at the end of each participant's session. The purpose was to obtain additional feedback that might not have been captured during the recording. The following procedure was used to debrief the participants:

- The researcher thanked the participant for taking part in the evaluation session.
- The participant was invited to comment about the testing content and procedure and what he/she felt might need further improvement. This question related both to improvements in *Instap!E4B* and to improvements in the testing procedure.

- The researcher presented questions to the participant about specific events (if any) during the test that might elicit further information from the participant.
- The researcher accompanied the participant out of the UT laboratory, indicating the end of usability testing session.

To enhance the quality of data collection during usability testing, all the sessions were observed and video recorded. This permitted the researcher to re-view the videos in order to compile and analyse the data.

Table 6.3: Profiles of the participants for main usability testing

	Profession / Occupation	**Age bracket (years)**	**Level of education**	**Computer experience**	**Computer experience (years)**
Participant 1	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 2	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 3	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 4	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 5	Junior academic staff	24-29	Postgraduate	Expert user	Over 5
Participant 6	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 7	Junior academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 8	Academic staff	30-35	Postgraduate	Normal user	Over 5
Participant 9	Support staff	36-40	Undergraduate	Normal user	Over 5
Participant 10	Junior academic staff	24-29	Postgraduate	Expert user	Over 5
Participant 11	Academic staff	24-29	Undergraduate	Expert user	Over 5
Participant 12	Academic staff	24-29	Postgraduate	Expert user	Over 5

6.6 Approach to data analysis and how to report results

The results of the data collection and analysis are reported in Chapter 7 using textual, graphical and tabular formats. Discussion on the findings will identify areas suitable for related future research. The overall description of the study and its results will be reported in the form of an MSc dissertation document and a draft conference paper.

6.7 Summary and conclusion

The chapter presented the design and methodology used in the study. It laid the foundations for addressing Questions 2 and 3 of the study, which are answered in Chapter 7.

It also provided important information regarding the procedures used in implementing the two UEMs, the usability measures, evaluation instruments, and profiles of the participants. This is necessary for conducting valid and reliable usability evaluation procedures. The overall design of a study and the processes used, contributes to getting reliable results.

Chapter 7, following, was conducted in line with the research design and methodologies set out in this chapter. The findings in Chapter 7 are based on data collected by the methods described in this chapter. This data was used in reporting the results of the study and analysing them.

CHAPTER 7: Data collection and analysis and discussion of results

7.1 Introduction

The main aim of a usability evaluation is to determine whether a system has usability problems. For an e-learning system such as *Instap!E4B*, the intention is particularly to identify those usability problems that may impact on learning. This study applied two usability evaluation methods (UEMs) to identify problems, namely:

- A user-based questionnaire, and
- Usability testing in a usability laboratory, as described in Section 6.4.

The use of two methods increased the reliability of the study, and as a secondary outcome of the study provided useful information on *Instap!E4B*. However, the main purpose of this research is to compare the findings of the two UEMs in order to answer Research Questions 2 and 3 in Section 1.4.

This chapter presents findings of the case study conducted to evaluate the target application, *Instap!E4B* by the two UEMs. In Section 7.2, the findings of the user questionnaire survey (learner survey) are given. Section 7.3 relates to the controlled usability testing (UT) in the HCI laboratory on the Muckleneuk campus of UNISA. The section presents the analysis of usability testing. Section 7.4 presents a comparison of the two methods. The effectiveness of using two UEMs for usability evaluation is considered in Section 7.5 and the chapter is concluded in Section 7.6. Chapter 7 thus plays the major role in answering Research Question 2 and its sub-questions, as well as Research Question 3 and its sub-questions.

7.2 Analysis of data from the learner survey

7.2.1 Pilot learner survey

The main purpose of a pilot study is to try out the research approach and methods before they are used in a main study. In this case, it also served to identify questions that required refinement and improvement before the main learner survey. The pilot was done in 2009. The eleven participants were a good representation of typical users and were similar to the intended sample for the main user survey. They were students and staff in tertiary learning institutions, aged between 19 and 40 years, being an age range of likely users. It was also a requirement that they were computer literate and technologically literate. The sample was representative with regard to demographic groupings, namely gender, age group and active students.

After the pilot study, certain evaluation statements were re-phrased and the following statements were added to the questionnaire in readiness for the main learner survey:

Table 7.1: Additional statements after pilot learner survey

No.	Statement
1	The system motivates me to learn.
2	I feel encouraged to participate.
3	*Instap!E4B* supports me when I make usability errors.
4	The audio interface (voice) improves learning

7.2.2 Main learner survey

Usability evaluation by questionnaire surveys is discussed in Section 3.4.1 and addressed again in the context of this study in Section 6.4. This section discusses the analysis of the data from the learner survey, which was undertaken in September 2010, and also considers the strengths and weakness of this UEM. As mentioned in

Section 6.4.5, the survey targeted 57 participants. Of the 57 questionnaires distributed, there were 50 respondents. This represents an 88% response rate. According to Gillham (2000b), any percentage above 40% is considered to be fair therefore this is a good response rate. The participants were obtained in Kenya and were not the same as those that took part in the usability testing. It also excluded participants from the pilot study. Additionally, they were not learners who actually used *Instap!E4B* in their studies, but they were representative of the typical user population of the system. Some of them had university qualifications and others were students.

This section, together with the previous section, contributes to answering Research Question 2:

> *What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?*

It specifically deals with the sub-question:

> *What usability and learning problems in Instap!E4B can be identified from evaluation by a user questionnaire survey?*

The theoretical criteria in Table 4.4 (in Section 4.5) were re-phrased as evaluation statements that participants could answer easily. The questionnaire is shown in Appendix A-III. Table 7.2 presents the questions/statements of the learner survey, with the associated criteria from Table 4.4 indicated in the third column. In some cases a single question is related to several criteria from different categories. In some cases, statements are not directly related to any criterion, resulting in the blanks in that column.

Table 7.2: Learner survey questions/statements and the related criteria

No.	**Statement**	**Related criteria from Table 4.4**
	General interface design	
1	The navigation links are readily available and visible throughout the learning sessions.	
2	The name of the system is appropriate.	2.3
3	The system's contents are interlinked (without dead ends).	
4	There are similarities between this system and others that I have come across.	2.3
5	The system enables me to control the pace of learning.	8.1
6	This system allows me to customise it to support my personal learning needs.	11.1; 11.3
7	The section for frequently asked questions (faq) is useful.	4.1; 12.1
8	I would prefer using *Instap!E4B* to classroom teaching when learning the English language for Business use.	1.2; 5.3
9	The online Help facility is useful.	9.2; 12.1
10	The system motivates me to learn.	3.2; 3.3; 10.1
11	I feel encouraged to participate.	3.5
12	The graphical presentations (icons) are easy to interpret.	2.3
	System interaction	
13	The home page of the system opens quickly.	
14	It is easy to understand the functions of the menu items.	2.3
15	The functions that I expect to find in the menu items are present.	2.3
16	The menu items of the system are well organised.	2.2
17	*Instap!E4B* is highly interactive.	2.1
18	I need not recall the system interface during learning sessions.	2.3
	Learner-centred instructional design	
19	There is a well-designed feedback mechanism within the system.	5.2
20	I am able to search for content that I cannot initially find easily.	5.3; 9.2; 12.1
21	This system engages me.	2.1; 3.1; 3.5; 10.1

22	The system provides the learning contents in a consistent manner.	2.2
23	Compared to books, the system has up-to-date contents.	10.1
24	The learning goals and objectives are made clear within the system.	1.1; 1.2
25	The learning content is current and accurate.	10.1
26	The learning contents are presented in a way that supports learning.	2.2
27	The animations aid learning.	
28	The audio interface (voice) improves learning.	7.3
29	This system presents the content in small understandable chunks.	2.2
30	The system's content is relevant for learning English for business.	10.1
31	The learning activities enable me to practise the learnt skills.	2.1
32	*Instap!E4B* supports different approaches to learning.	2.1; 3.1
33	The system has flexibility in addressing needs of different learner.	11.1; 11.2; 11.3
34	*Instap!E4B* supports deep learning.	4.1
35	The fact that learning materials are provided on multiple windows, supports learning.	
	System's navigation and orientation	
36	It is easy to explore the different parts of *Instap!E4B*.	11.1
37	It is easy to get back to the home page.	7.1; 11.1
38	The system's navigation setup enables me to access different contents easily.	11.1; 11.2; 11.3
39	There are different ways of accessing the functions of the *Instap!E4B*.	11.1; 11.3
40	I generally find it easy to use the system.	11.1; 11.2
41	It is easy to know where I am in the system.	7.1; 7.3
42	*Instap!E4B* can supplement classroom learning of English language for Business.	
43	The learning tasks have tolerance for user errors that are related to learning, i.e. cognitive errors.	9.1; 9.2; 9.3
44	*Instap!E4B* supports me when I make usability errors.	9.1; 9.2; 12.1

Appendices B-I, B-II, B-III and B-IV provide details of the rating of each of the statements in the questionnaire.

Table 7.3 categorises the problems that the participants encountered in the context of the criteria. The frequency count of each problem is divided by 50 (the number of participants in the learner survey) before multiplying to calculate the percentages.

Table 7.3: Set of problems identified by participants

No.	Usability problem	Frequency	Percentage (%)
1	**Clear learning goals, objectives and outcomes**		
	• The learning goals of a chapter in the system are not clear at the beginning of a session.	5	10
	• The chapters do not have an introduction that can inform the learners of what is expected.	6	12
2	**Suitable presentation of domain and engaging learner**		
	• The system does not engage learners on practical aspects of the learning during a session.	1	2
	• The presentation of knowledge in the chapters is not appropriate to the learning context.	10	**20**
	• There are cases where there is no match between the symbols, icons and names. Some icons are not suitable for adult learners' level.	8	16
3	**Support for learning activities**		
	• The system does not support learner activities that enable understanding of the new knowledge acquired.	2	4
4	**Elicit learner understanding**		
	• The system's exercises are not appropriate when compared to the content of the chapters.	4	8
	• The new contents do not incorporate existing skills and learners' prior knowledge.	4	8
5	**Feedback for formative evaluation**		
	• When a learner gets a question wrong, the system's feedback does not inform one on how to proceed.	6	12
	• The feedback does not improve learners' performance and confidence to learn.	11	**22**
	• There is limited feedback that is in audio format.	5	10

6	**Support for 'self-learning' skills transfer** • The learning system does not support transfer of learnt skills to the learners' related activities and daily lives.	2	4
7	**System status should be visible** • The system does not keep the learners informed about what is going on. • The feedback mechanism of the system is weak.	12 9	**24** 18
8	**Appropriate learner control** • In some cases the system restricts the interface to be used, that is, some learning content does not have an audio interface and shortcuts. • The system does not have Undo and Redo facilities.	11 6	**22** 12
9	**Cognitive error recognition, diagnosis and recovery** • When learners make user errors, the system has minimal assistance to them out of such errors. • There is no adequate Help facility to guide learners to recover from cognitive errors.	8 7	16 14
10	**Recognition rather than recall** • Instructions on how to perform some tasks are not visible. • There is no clarity on what function an icon is supposed to perform.	12 11	**24** **22**
11	**Active learning and learner motivation** • The learning system does not promote creativity from the learners. • There are limited features that can keep a learner attracted to the system.	4 7	8 14
12	**System's flexibility and efficiency** • The system lacks shortcuts for frequent or expert users. • System does not support learners to adjusting settings to suit their needs.	10 3	**20** 6
13	**Help facility** • The Help facility is limited in its content and capability.	14	**28**

In Table 7.3 the problems mentioned by 20% or more of the participants are printed in bold. They relate to the following matters:

1. *The presentation of knowledge in the chapters of Instap!E4B is not appropriate to the learning context.* Knowledge presented in the learning content chapters is focused on commerce as the context of use. This restricts the scope of Business English, which is also used in other fields like engineering. In addition, it would have been appropriate if the content had been presented in different levels of complexity. This would allow a learner to move from one level to another after achieving the learning objectives of a lower level.

2. *The feedback does not improve learners' performance and confidence to learn.* Over and above certain situations where the feedback gave a wrong answer, most of the system's feedback was found to be limited. Feedback should be presented to encourage and motivate learners through the learning sessions.

3. *The system does not keep the learners informed about what is going on.* For instance, when a participant is working on the exercise part of the session, it could have been helpful to have a status bar that indicates the question being attempted and probably its expected learning objectives.

4. *The system restricts the interface to be used, that is, some learning content lacks an audio interface and shortcuts.* The system does not have shortcuts that can lead a learner to a previous page. Such shortcuts are handy if they can be accessed from the menu that is obtained from right-clicking the mouse.

5. *Instructions on how to perform some tasks are not visible.* When a learner opens a chapter, it is not clear how to approach the content of the chapter. The system does not have a mechanism for informing the participants that they can use the audio interface in addition to reading the content.

6. *There is no clarity on what function an icon is supposed to perform.* The system has two buttons for Help. One is for the learners while the other is for the educator to customise the system. There are also two buttons for accessing the exercise yet they have different names. Such situations are likely to confuse a learner.

7. *The system lacks shortcuts for frequent or expert users.* This is incorporated in Problem 4.

8. *The Help facility is limited in its content and capability.* The number of words and context in the system are limited. This has to rely on updates to the system. Furthermore, the Help facility is limited in assisting a learner how to attempt the exercises.

The next section discusses the analysis of ratings of statements from the questionnaires.

7.2.3 Analysis of ratings of statements

This section considers the top ten statements as rated by the 50 participants and the lowest ten. Section 7.2.3.1 presents the ten statements rated highest, while Section 7.2.3.2 relates to the ten statements rated lowest.

7.2.3.1 Top ten rated statements

Table 7.4 shows the ten statements rated the highest on a Likert scale of 1 (strongly agree) to 5 (strongly disagree), ranked from the highest mean rating to the lowest. Since all respondents answered all questions, the frequency (50) is not included in the table. The *mean rating* column represents the average of the responses per statement. The highest rated was the statement that *Instap!E4B* supports different approaches to learning, which had a mean rating of 1.4 on the Likert scale. Close to that, the rapid opening of the home page and the animated learning aids of the system both returned high ratings of 1.5. These statements represent strengths in *Instap!E4B.*

Table 7.4: Top ten rated statements

No.	Statement	Mean rating [Likert]
1	*Instap!E4B* supports different approaches to learning.	1.4
2	The home page of the system opens quickly.	1.5
3	The animations aid learning.	1.5
4	The system enables me to control the pace of learning.	1.6
5	The audio interface (voice) improves learning.	1.7
6	There are similarities between this system and others that I have come across.	1.8
7	The name of the system is appropriate.	2.0
8	There are different ways of accessing the functions of the *Instap! E4B*.	2.3
9	The learning activities enable me to practise the learnt skills.	2.3
10	The section for frequently asked questions (faq) is useful.	2.3

7.2.3.2 Lowest ten rated statements

Table 7.5 shows the ten statements rated the lowest on a Likert scale of 1 (strongly agree) to 5 (strongly disagree), ranked from the lowest mean rating to the highest. This means that Statement 1 in the table, with a mean rating of 3.6, was rated the lowest of the 44 statements in the questionnaire. These ten statements are the statements that represent likely usability problems in *Instap! E4B*. The worst rated was the statement about the system's tolerance for user errors related to learning (i.e. cognitive errors) with a mean rating of 3.6 on the Likert scale. The lack of support for deep learning within *Instap!E4B* returned a poor rating of 3.5.

The participants gave poor assessments to the system's support for learning. This is shown by the ratings assigned to Statements 2, 3 and 5.

Table 7.5: Lowest ten rated statements

No.	Statement	Mean rating [Likert]
1	The learning tasks have tolerance for user errors that are related to learning, i.e. cognitive errors.	3.6
2	*Instap!E4B* supports deep learning.	3.5
3	The system motivates me to learn.	3.4
4	I feel encouraged to participate.	3.2
5	The fact that learning materials are provided on multiple windows, supports learning.	3.2
6	*Instap!E4B* supports me when I make usability errors.	3.2
7	The system has flexibility in addressing needs of different learner.	3.1
8	Compared to books, the system has current content.	3.0
9	The learning content is current and accurate.	3.0
10	It is easy to get back to the home page.	3.0

In Table 7.5 the ratings of Statements 8 and 9 show that the participants did not feel that the content of the system was current.

As shown in Table 7.2 in Section 7.2.2, the questionnaire is divided into sections for:

1. general interface design,
2. system interaction,
3. learner-centred instructional design, and
4. navigation and orientation.

The findings of each section are now discussed separately.

7.2.4 Analysis of general interface design

Appendix B-I presents the consolidated responses to questions intended to obtain participants' opinions regarding the first category, namely: design of the interface of

Instap!E4B. Figure 7.1 below is a graphical depiction of the final line of the table in Appendix B-I, and summarises responses regarding the system's interface in general.

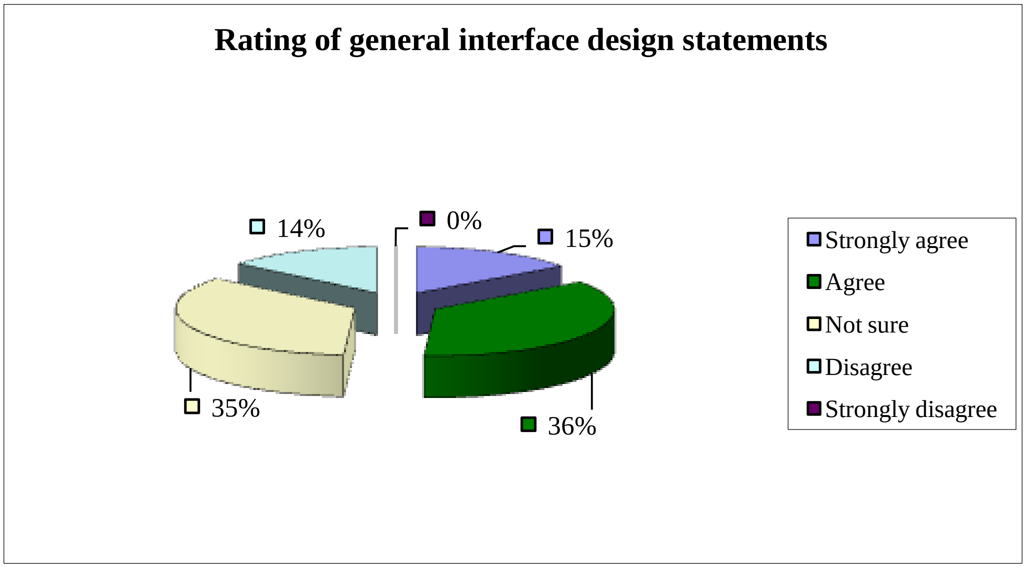

Figure 7.1: Rating of general interface design

For the general interface design (Appendix B-I and Figure 7.1), 15% of the participants, on average, strongly agreed that the system was satisfactory, while 36% of them agreed that the system had a good interface. That implies that 51% (15%+ 36%) of the participants were satisfied with the interface design of *Instap! E4B.* However, 35% of the participants were unsure, that is, they had no strong feelings on the interface design in general. Only 14% of them disapproved and none of the participants selected the 'strongly disagree' option. That gives the system a reasonable approval rating of its interface, which is a highly important usability aspect of an e-learning system.

In Appendix B-I, the responses to Statement 10 indicate that half of the respondents were not satisfied that the system could motivate learning, with another 40% not being sure about it. Only 24% of the participants indicated that they felt encouraged to learn (Statement 11). These statements relate to a lack of ease of learning with *Instap!E4B* and the findings are a cause for concern.

The participants gave low approval ratings for certain aspects that indicate usability problems in *Instap!E4B*. For instance, only 34% approved of the interlinking the system's contents (Statement 3). There was a 36% (10% and 26%) preference for using *Instap!E4B* instead of conventional classroom learning for Business English (Statement 8). Conversely, that implies that 64% of the participants did not prefer using *Instap!E4B* for learning English for Business use. In Statement 9, the usefulness of its online Help facility received 48% (20% and 28%) approval ratings from the participants. Furthermore, the participants felt that the graphical presentations were not easy to interpret, giving them an approval rating of only 38% (12% and 26%) (Statement 12).

The study also identified statements that had high acceptance rates from the participants. There was 58% approval for the statement indicating that the system's navigation links effectively support learning (Statement 1). A system should have good navigation links (Dix, A., Finlay, J., Abowd, G. & Beale, R., 2004). As investigated by Statement 4, there should be similarities between a system and others (Dix *et al*., 2004; Squires & Preece, 1999). For example, Dix and his co-authors advocate familiarity, generalisability and consistency. The statement related to this got high approval with an average 1.8 Likert scale rating (Statement 4). The self-paced learning was also highly rated with an average of 1.6 (Statement 5).

7.2.5 Analysis of system's interaction

Appendix B-II presents responses from the survey participants to the questions on the interaction capabilities of *Instap!E4B* and how it supported them as they used it during the process of working through the activities. Figure 7.2 shows a summary of the responses for the second group of questions, namely those on system interaction.

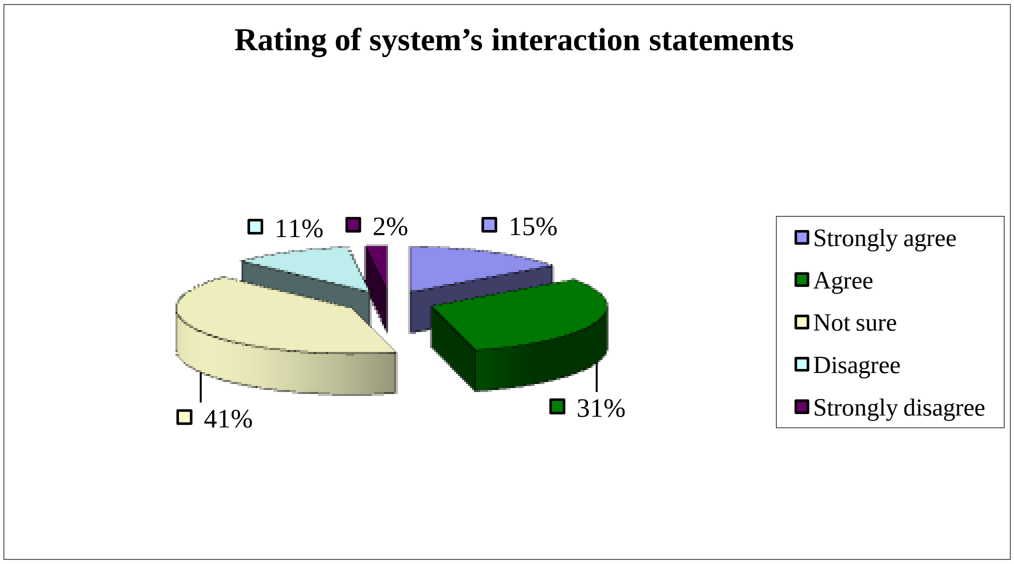

Figure 7.2: Rating of system's interaction statements

The discussion that follows is related to the results reported in Appendix B-II. With respect to the statement that in an e-learning system, the home page should open quickly, *Instap!E4B* received a strong average Likert rating of 1.5 (Statement 1). With regard to the ease of understanding the system's functions as presented in the menus, only 38% (14% and 24%) of the participants were positive (Statement 2). This implies a need to address the menus to improve the system's navigation and orientation, this is also being the focus of the fourth category which is discussed in Section 7.2.7.

Responding to the statements that the menu items are well-organised (Statement 4) and that *Instap!E4B* is highly interactive (Statement 5), 28% and 34%, respectively, agreed. This was offset by the 14% *strongly disagree* response with respect to the interactivity (Statement 5). The mean rating for each of these statements therefore is score of 2.9 on the Likert scale rating, indicating potential usability problems.

The interfaces of an e-learning application should be easily recognisable by learners. This can be achieved by making them similar to those of systems in common use. With regard to the issue of being able to recognise matters on the interface rather than having to recall them (Statement 6), only 36% approval was assigned, with 60% expressing uncertainty and 4% of them expressing disapproval.

7.2.6 Analysis of learner-centred instructional design

Appendix B-III presents the responses relating to participants' views on the third category, namely: the system's instructional design and how it supports learner-centricity. Figure 7.3 summarises the responses to the statements on learner-centred instructional design.

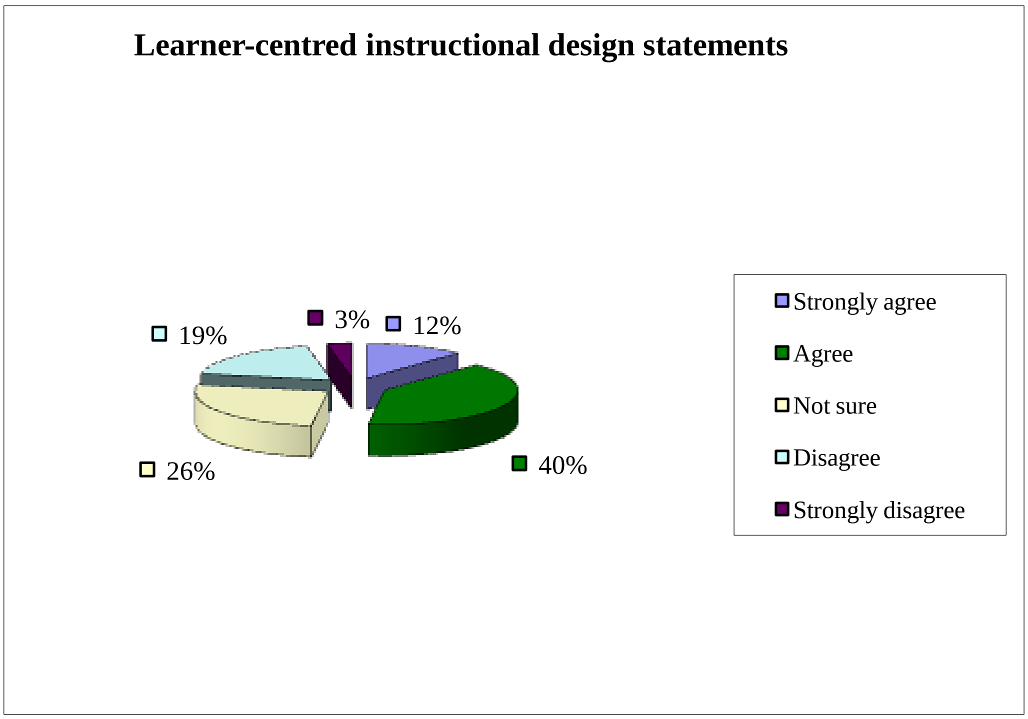

Figure 7.3: Ratings for learner-centred instructional design statements

The following discussion is about the ratings depicted in Appendix B-III. Good learner-centred design is the basis of a successful e-learning system. For this reason, this section of the questionnaire, which relates more to issues of learning than to the usability of *Instap!E4B*, contained the largest number of questions.

In the mean rating (%) shown in Figure 7.3, a total of 52% (12% plus 40%) of the responses were affirmative about the general learner-centred design of *Instap! E4B.* However, there was a 22% (19% 'disagree' plus 3% 'strongly disagree') disapproval of its design with relation to learner-centred instruction. Well-designed e-learning application software should engage the learners (Albion, 1999; Alessi & Trollip, 2001; Squires & Preece, 1999; Vrasidas, 2004). Only 28% of the participants found *Instap!E4B* to be engaging (Statement 3).

When compared to textbooks, the content of electronic learning systems should be up-to-date (Albion, 1999; Alessi & Trollip, 2001). Many respondents agreed, but there were also a number who disagreed, bringing the rating on the Likert scale to 3.0 in Statements 5 and 7. Whereas the two statements had 50% and 44% respectively of approvals, these were offset by 14% and 12% respectively of strong disapprovals. This resulted in the above-shown Likert scale ratings and therefore indicate a potential usability problem as for the case system's interaction in Section 7.2.5. The system was also found to lack the flexibility to support different learners' needs (Statement 15). This aspect scored an average Likert scale rating of 3.1.

7.2.7 Analysis of system's navigation and orientation

Appendix B-IV presents the responses from the participants in the learner survey regarding the fourth category, system navigation and orientation. The chart in Figure 7.4 summarises the responses for these aspects.

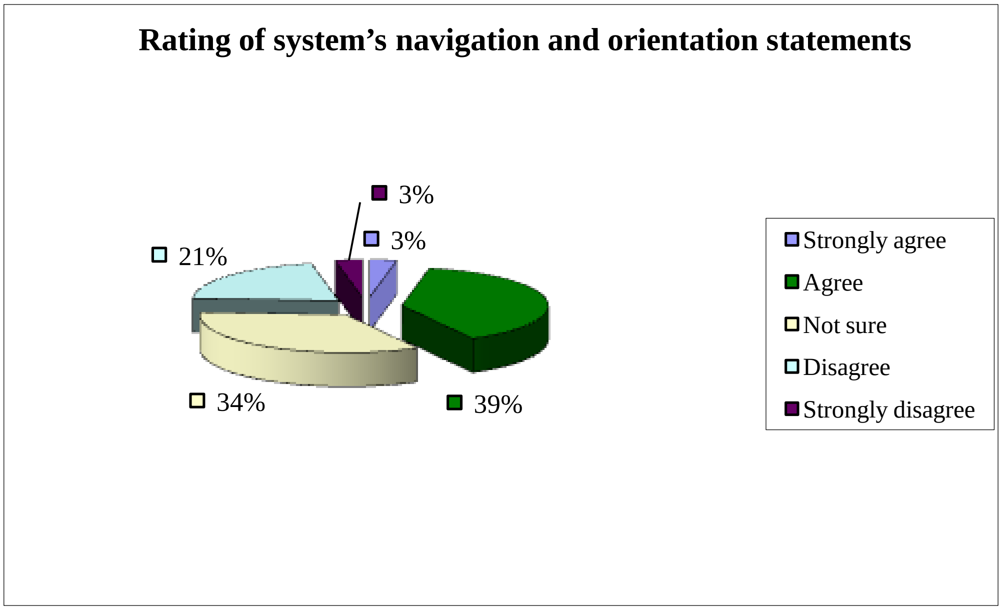

Figure 7.4: Ratings for system's navigation and orientation statements

From Figure 7.4 and Appendix B-IV, there was an approval of 42% (3% plus 39%) on the mean ratings of responses about the system's navigation and orientation. Another 34% of participants had no strong feelings about its navigation and orientation. This finding indicates that there might be a need to improve that particular aspect.

The responses in Appendix B-IV indicate that more participants did not agree than agreed that it was easy to get back to the system's home page. Only 34% agreed that it is easy to go back to the home page (Statement 2). This being a usability problem, it can be improved by including a site map. The participants also indicated the need for improving error recovery for the system. Only 20% approved of the application's error recovery interface (Statement 9). To encourage meaningful learning, an e-learning tutorial should have a well-designed error recovery system. This aspect got a poor score of 3.2 on the Likert scale. The participants also disapproved of the system's tolerance for user errors, with a Likert scale rating of 3.6 (Statement 8).

The learners agreed that the system was easy to explore, giving it a Likert scale rating of 2.8 (Statement 1). This was also the case with the use of the system to supplement classroom learning with a Likert scale rating of 2.7 (Statement 7).

In this section, Tables 7.3 and 7.5 mainly answered the sub-question of Research Question 2 that intended to determine:

> *What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?*

The next section is an assessment of the use of questionnaire surveys among learners as a UEM.

7.2.8 Discussion of learner survey evaluation as a UEM

This section presents an assessment of the data that was captured during the user questionnaire survey and makes mention of related issues in usability testing (see Section 7.3).

- The data analysis showed the capability of a questionnaire survey to obtain a larger amount of quantitative data than usability testing. This is because it is administered in a format that can capture a great deal of different information by obtaining participants' opinions on a broad range of issues. The high number of questions in the questionnaire provided the researcher with a large amount of information from the participants. It was completed in the participants' own time, without the researcher being present. Analysis of this large amount of data consumed time, but the time spent per unit of data is much less than with usability testing.

- This information is gathered and analysed in a cost-effective way, compared to usability testing in a controlled laboratory environment using sophisticated equipment. The work involved in collecting and processing data in usability testing is much more time-intensive.

- The number of participants in user surveys can be large and this strengthens the findings of the collected quantitative data, making them reliable.

- It should be noted that user surveys require a large number of respondents to maintain validity of findings. In this case 50 participants responded out of the intended total of 57. Due to lack of direct observation of the evaluation, as is the case in usability testing, there may be instances where the researcher has to rely on the integrity of participants' responses, without being certain of the sincerity of the participant in giving his/her responses.

The next section discusses analysis of the usability testing with a view to providing a comparison of the two UEMs later in the study.

7.3 Analysis of usability testing

The discussion that follows is an analysis of the usability testing (UT). It briefly presents the pilot usability testing in Section 7.3.1, thereafter discusses the main usability testing in Section 7.3.2.

7.3.1 Pilot usability testing

The pilot usability testing sessions were conducted in June 2009 in the HCI laboratory at UNISA. Four participants were drawn from staff of the UNISA School of Computing. Although these participants were not real-world users of the Instap!E4B e-learning software, they were typical of the type of users with regard to their ages and occupations. Table 6.2 in Chapter 6 gives the profile of the participants.

The pilot UT included qualitative aspects that were studied by observation in the controlled environment. The focus of the pilot was to adjust the usability tasks for evaluating *Instap! E4B.* After noting where the participants in the pilot test struggled to understand the requirements, the following adjustments were made to the usability testing tasks:

- Certain subtasks were re-phrased to give them more clarity.
- The actual tasks document was re-formatted by italicising the guidelines.
- A further important change made to the main study after the pilot UT was that additional standard quantitative usability metrics were incorporated, so as to measure participants' performance. Examples of these were: time taken on tasks, number of errors made, time taken to recover from errors, and so on.

The researcher also reconsidered the evaluation statements in the questionnaire that accompanied the usability testing. Some were re-worded and others were added to obtain additional information. Since the times taken to complete the tasks was known from the pilot study, it was easier to plan the main study. With regard to duration of the sessions, time was also needed by the facilitator to save the video file before setting up for the next participant.

The researcher noted the value of a pilot study, since it helped in preparations for the main task. This view is supported in other studies that view a pilot as a necessary step towards adjusting the design of the main study (Meriwether, 2001; Van Teijlingen and Hundley, 2010).

7.3.2 Main usability testing

Usability evaluation by controlled usability testing is discussed in Section 3.4.3 and addressed again in the context of this study in Section 6.5. This section analyses the results of the main usability testing that was conducted in October 2011 in the HCI laboratory at UNISA. As mentioned in Section 6.5.4, it involved twelve participants whose profiles are provided in Table 6.3 in Chapter 6. Most of the participants (8) were junior academic staff at UNISA. They were in the age range 24–29 years which represents an age group of a large portion of learners likely to use the system. Although the participants were not actual students using *Instap!E4B,* they are a true reflection of typical members of the intended population as required by Davis and Shipman (2011). As mentioned in Section 4.2, the use of stereotypical users is also important in addressing the interaction design of a system.

The discussion in this section contributes to answering Research Question 2:

> *What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?*

It specifically deals with the sub-question:

> *What usability and learning problems in Instap!E4B can be identified from evaluation by usability testing?*

There were two tasks to be done in the UT sessions:

Task 1: Explore *Instap!E4B* and its help facility.

1.0 From the main screen,

Explore the buttons on both the top and bottom toolbars without clicking.

1.1 On completing, the above,

Click the “Help” button (“Explanation about the screen”). You may take some two to three minutes to read the default screen.

On completing, do **NOT** close that screen.

1.2 While on Help screen,

Click on “Index” tab, then from the menu select “Lesson overview”.

Take some time to read the screen content.

1.3 After reading the screen content,

Close the “Help” screen to go back to the main screen.

Task 2: A learning and exercise session

2.1 On the main screen,

Go to (select) the chapter on "Organisation".

Making use of the "Listen" button, study the chapter's section on "Japan feels the heat of competition".

Do **NOT** close the screen.

2.2 Attempt the exercise about the chapter as guided below:

Select "Practice" from the bottom toolbar,

Under "Subject" menu, select the option for "Grammar"

Do the first TWO exercises by clicking on the "Do the exercise" button at the bottom left corner of the screen.

The actual task list is shown in Appendix A-IV.

Table 7.6 presents details of the usability testing tasks, associating them with the criteria on which they are based.

Table 7.6: Usability testing and the related criteria

Tasks	**Related criteria from Table 4.4**
1.0 From the main screen, • Explore the buttons on both the top and bottom toolbars without clicking.	2.2; 2.3.
1.1 *On completing, the above,* • Click the "Help" button ("Explanation about the screen"). You may take some two to three minutes to read the default screen. • On completing, do **NOT** close that screen.	9.2; 12.1.
1.2 *While on Help screen,* • Click on "Index" tab then from the menu select "Lesson overview". • Take some time to read the screen content.	1.1; 1.2; 2.1; 2.2; 3.1; 3.5; 5.2; 5.3; 9.2; 10.1; 12.1.

1.3 *After reading the screen content,* • Close the "Help" screen to go back to the main screen.	11.1; 7.1; 11.2.
2.1 *On the main screen,* • Go (select) to the chapter on "Organisation". • Making use of the "Listen" button, study the chapter's section on "Japan feels the heat of competition". • Do **NOT** close the screen.	1.1; 1.2; 2.1; 2.2; 3.1; 3.5; 5.2; 5.3; 9.2; 10.1; 12.1.
2.2 *Attempt the exercise about the chapter as guided below:* • Select "Practice" from the bottom toolbar, • Under "Subject" menu, select the option for "Grammar" • Do the first TWO exercises by clicking on the "Do the exercise" button at the bottom left corner of the screen.	1.1; 1.2; 2.1; 2.2; 2.3; 3.1; 3.2; 3.3; 3.5; 5.2; 5.3; 7.3; 9.2; 10.1; 12.1.

Table 7.6 has its foundation in Table 4.4 of evaluation criteria appropriate for this study, hence the criteria indicated in the third column.

7.3.2.1 Task 1: Exploring the system and its Help facility

This task was intended to the give the participants an overview of the system and show them where to get assistance (Help facility). The Help facility was included, because users of any system should be aware of the first point of assistance in the event of getting stuck. As indicated in Table 4.4 Criterion 12.1, the access to help facilities is particularly important for e-learning systems. Users should be able to use the system before they can begin to actually learn. All the participants were able to complete this task without difficulties and therefore it served the intended purpose of preparing them for the next task.

They all took at least a minute to read the content of the Help page, after which they closed it to go back to the system. No errors were recorded during this task.

In the debriefing after the tasks were both completed, a short questionnaire was administered see (Appendix A-IV). The responses to evaluation statements about

Task 1 are analysed in Table 7.7.

Table 7.7: Evaluation statements about Task 1 from post-session questionnaire

	Evaluation statement in questionnaire	**No. of participants who agreed**	**Percentage of participants who agreed**
1	The online Help facility is useful.	8	67%
2	It is easy to understand the functions of the menu items.	7	58%
3	The interface guides the users well (does not mislead users).	7	58%
4	The functions that I expected to find in the menu items were present.	8	67%

From Table 7.7, it can be seen that the participants returned good ratings (67%) for the Help facility and for familiarity of the system. This indicates that they had obtained some level of assistance from the Help interface to effectively complete a task. The participants who were not satisfied with the Help facility expressed concern that its content was shallow and had limitations in giving a reply regarding content that was unavailable in the system's Help. Understanding of the menu items and the system's interface scored 58%, which is not good enough, indicating some usability problems. The other participants had reservations about understanding the functions of the menu items, mainly because of the way in which they were arranged. This is further reflected in Question 3 about how the system's interface guides users. Only 58% of the participants agreed with the way the interface guides users. Regarding functions anticipated to be in the menu, 67% of the participants found the menu items they expected.

During Task 1, it was observed that the participants did not immediately find where the Help facility button was located. In one instance, a participant was confused, because there was another Help icon on the left hand side of the toolbar. That one was meant for the instructors, being the one that the instructor uses to customise the system. Three of the participants went around clicking the system's icons as they explored it. It was noted in one instance that when a participant could not find the way back to homepage, he closed the interface and restarted the system.

7.3.2.2 Task 2: Learning and exercise session

Task 2 involved a learning session followed by a testing exercise, to assess the skills that the participants had learnt. The task, therefore, aimed to give the 'feel' of a real learning session. The task gave a participant the opportunity to learn Business English by going through the content of a chapter. On completing the specified chapter, a participant was expected to attempt an exercise to test how much knowledge had been acquired.

The system's interface was expected to support the participants through the task. Table 7.8 shows situations that were observed by the researcher while participants were doing Task 2, all of which have a bearing on the system's usability. The table is based on errors made and assistance that the participants received from the system's Help facility or from the researcher.

Table 7.8: User errors and assistance during Task 2 from the researcher's observation

No.	**Observations by the researcher**	**No of participants who encountered the situation**	**Percentage of participants who encountered the situation**
1	A participant got stuck (user errors).	12	100%
2	A participant was assisted to recover.	10	83%
3	A participant recovered from user error without researcher's assistance.	6	50%
4	A participant accessed the Help facility.	10	83%

Table 7.8 shows that all the participants were stuck in user errors at least once. Of these participants, three got into an error after deliberately trying to see how the system would behave in such situation. Such errors help a learner to learn more, as discussed with regard to cognitive errors in Chapter 3. Eighty-three per cent got some assistance from the researcher to recover from a user error. Half of the participants were able to recover from user errors without any assistance. Eighty-three per cent accessed the Help facility during the task. The section that follows discusses the participants' activities based on usability measures and the content of Table 7.8.

7.3.3 Usability testing metrics during usability testing sessions

Table 7.10 at the end of Section 7.3.3.2 consolidates the results in a comprehensive table. To set the scene, various aspects are first considered individually. This section therefore focuses on subsets of the usability metrics obtained during the testing session.

7.3.3.1 Number of times accessing Help facility

When participants encountered error situations, they would either be assisted by the Help facility, take some time to find their way out, or rely on the researcher.

Table 7.9: Comparison of user errors and access to help facility

	Error situation (Frequency)	**Used Help facility**	**Did not use Help facility**
Error recovery (unassisted)	9	4	5
Error recovery (assisted)	30	8	22

Table 7.9 gives a comparison of the users' errors situations and how they relate to accessing the Help facility. Table 7.9 shows nine cases of recovery from user errors that were unassisted, while there were 30 assisted recoveries. For the participants

with unassisted recovery from user errors, four of them did so after seeking assistance from the system's Help facility. Table 7.9 and Figure 7.5 show that, in the 12 where participants recovered from errors by using Help, eight of them were assisted in doing so, while four of them were not assisted. It indicates that the Help system was inadequate. The table lists the frequency of these errors and indicates whether the participant got assistance from the researcher. In cases of unassisted error recoveries, some users made use of the Help facility while others independently figured out the solution. In most of the 22 cases of assisted error recoveries where participants did not independently use Help, they were taken through the steps in the Help facility by the researcher. Alternatively, the researcher directly provided advice that helped them to solve the problems.

Figure 7.5 presents the information in Table 7.9 in a graphical format.

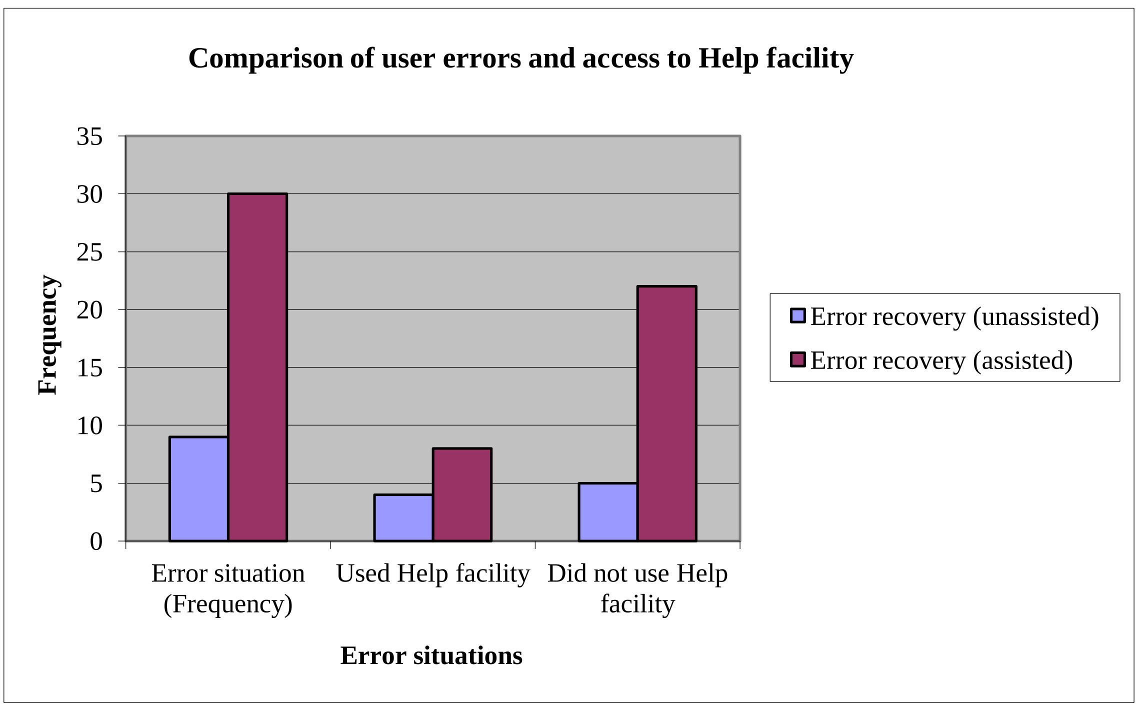

Figure 7.5: Comparison of recovery from errors

For the learning part of the sessions, all participants appreciated the importance of an audio (voice) interface as they went through the session. It was also observed that during the exercise part of the task, the learners spent more time on the beginning of an exercise. This is because the interface is not clear about what is expected in the process of answering a question. Four of them had to be guided regarding how to continue with the exercises after answering a question.

The subsection that follows gives further details of errors in usability testing sessions, based on the usability metrics that were recorded.

7.3.3.2 Number of times participants were stuck (in user errors)

On average, the participants were stuck 3.2 times. Six participants (50% of participants) were stuck more times than this average. That was an indication that the interfaces need to be revised to minimise interruptions to learning sessions. Of the above-mentioned six participants, five spent more than the average time (18.9 minutes) to complete the tasks. This demonstrates that being stuck slows down learners and distracts them during their interaction. It is worth noting that *Participants 5* and *12* were stuck only once and twice respectively and took shorter times to complete tasks. *Participant 5* took 16 minutes to complete the tasks while *Participant 12* took 11 minutes, this being the shortest time of all the participants.

Table 7.10 provides a detailed account of the test participants' numbers of activities during their usability testing sessions. The usability measures that are used, as mentioned earlier, are based on those presented in Section 6.5.1 in Chapter 6.

The video recordings made during the UT sessions enabled the researcher to further monitor situations by re-viewing activities iteratively after the sessions. This facilitated the analysis process.

Table 7.10: Summary of usability testing sessions (based on quantitative measures)

	Participant 1 (f)	Participant 2 (f)	Participant 3 (f)	Participant 4 (f)	Participant 5 (f)	Participant 6 (f)	Participant 7 (f)	Participant 8 (f)	Participant 9 (f)	Participant 10 (f)	Participant 11 (f)	Participant 12 (f)	Average frequency (f)
Time taken to complete tasks (minutes)	20	21	25	18	16	26	15	20	16	15	24	11	18.9
Number of commands used	29	32	33	28	29	36	27	31	29	28	33	25	30
Number of errors made	4	5	4	4	1	4	2	3	2	4	4	2	3.2
Number of error messages	0	0	1	0	0	0	0	0	0	1	0	0	0.2
Recovery time from errors (minutes)	3	4	4	4	1	9	1	5	5	3	5	2	3.8
Number of assisted recoveries	3	3	4	3	0	4	2	3	2	2	4	0	2.5
Number of unassisted recoveries	1	2	0	1	1	0	0	0	0	2	0	2	0.8
Number of times accessing Help facility	1	1	1	2	2	2	1	2	3	0	2	0	1.5

7.3.3.3 Recovery time from errors

Table 7.10 shows that the overall average time for participants to recover from errors during the sessions was 3.8 minutes. The minimum time was 1 minute and the maximum 9 minutes. There were seven participants (58% of participants) whose recovery time was higher than the average. This calls for an improved interface in *Instap!E4B* that can shorten the recovery time after an error. Figure 7.6 compares the time taken by each participant to recover from errors with the time taken by that participant to complete the tasks, confirming that the less time spent on error recovery, the shorter the overall completion time.

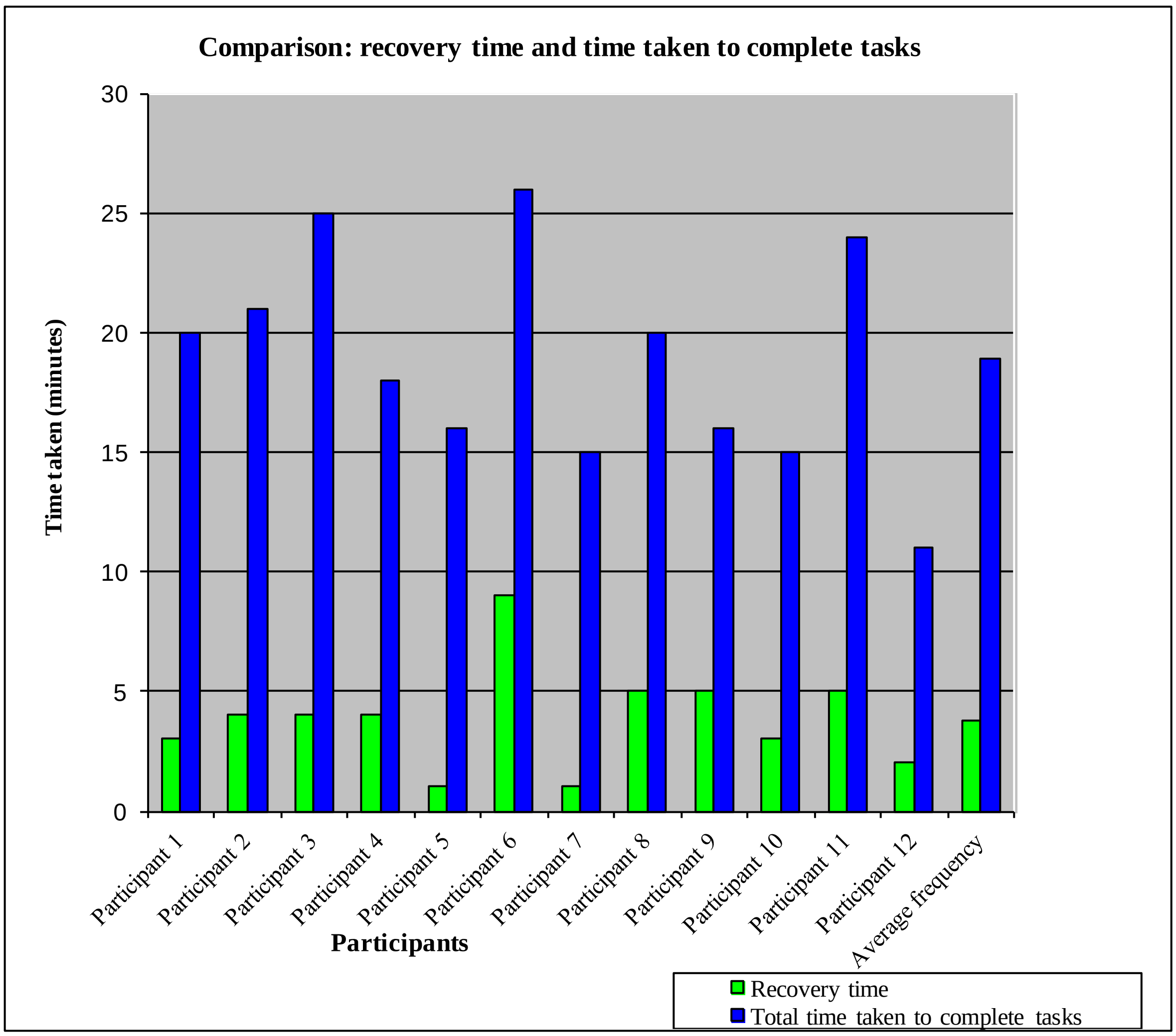

Figure 7.6: Comparison of recovery time from errors versus time taken to complete tasks

7.3.3.4 Time taken to complete tasks

All the participants successfully completed the two tasks. This was largely a consequence of:

- the refinement of tasks after the pilot study,
- ease of understanding the instructions, and
- communication between the participants and the researcher.

The average time taken to complete the tasks was 18.9 minutes as shown in Figure 7.6 and Table 7.10. *Participant 6* took 26 minutes to complete the tasks, of which 9 minutes were spent being stuck and recovering from errors. This participant was stuck 4 times but took longer to recover from each error even when being assisted. *Participant 3* took 25 minutes to complete the tasks and was stuck four times. This was the second-longest time taken to complete the tasks. This participant was assisted four times and had an average recovery time from errors of one minute. *Participant 11*, who took the third-longest time to complete the tasks, was assisted four times after getting stuck an equal number of times. The average recovery time for this participant was 1.25 minutes. Table 7.11 presents comparisons between times taken to complete the tasks and the number of times a participant was stuck, for the three participants who took longest to complete the tasks.

Table 7.11: Comparison between time taken and number of user errors for three participants with longest time for the tasks

	Usability metric	**Participant 3 (f)**	**Participant 6 (f)**	**Participant 11 (f)**
1	Number of times stuck (user errors)	4	4	4
2	Recovery time from errors (minutes)	4	9	5
3	Number of assisted recoveries	4	4	4
4	Time take to complete tasks (minutes)	25	26	24

These three participants were each stuck in user errors four times and took at least one minute for the assisted recovery. This comparison is also shown in Figure 7.7.

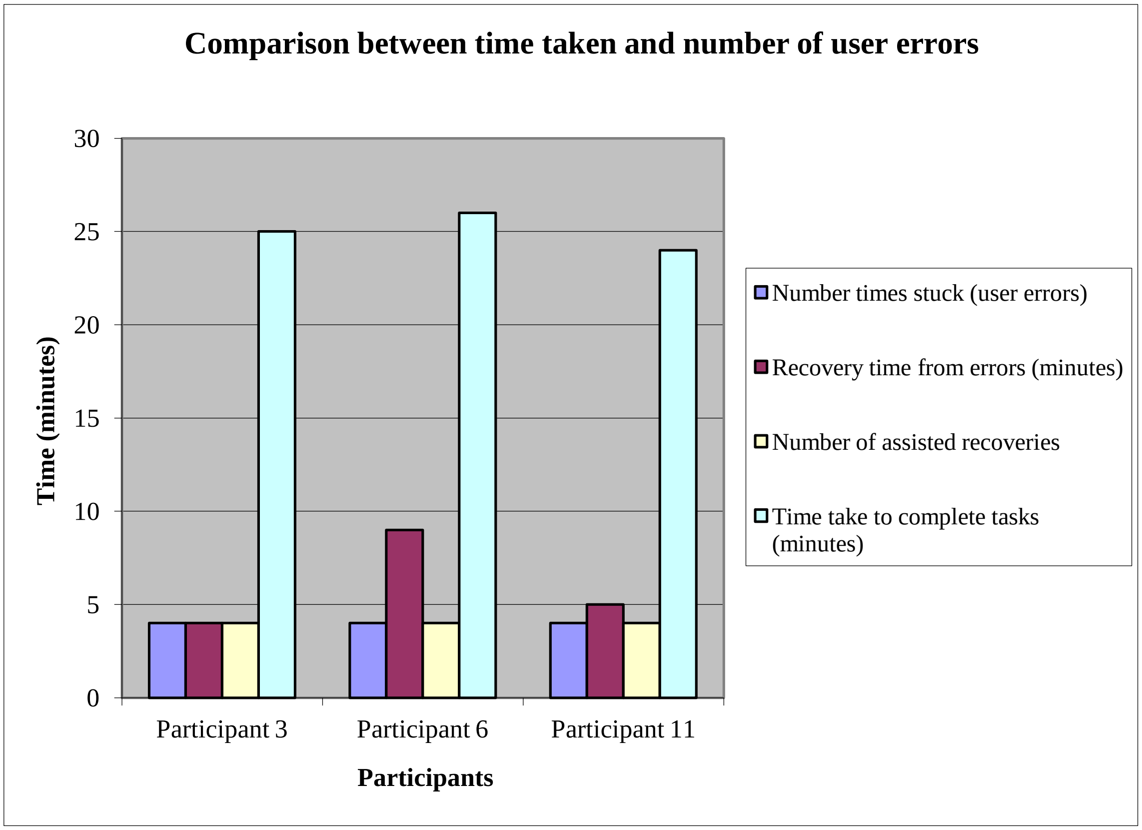

Figure 7.7: Comparison between time taken and number user errors for three participants with longest time for the task.

In Figure 7.7, it is evident that *Participants 3* and *11* took at most five minutes to recover from errors. That represents about 20% of the total time that each of them took to complete the tasks. That is a significant amount of valuable learning time was unfortunately lost in being stuck in user errors.

7.3.3.5 Assisted recoveries

On average, the participants were assisted 2.5 times when stuck. Considering that participants made on average 3.2 errors, that fact that they were assisted on average 2.5 times, is serious. For seven participants (58%), the number of times they were assisted, was more than the average mentioned above. The researcher came to the assistance of participants when they spent about 15 seconds staring at the screen and/or clicking on links that were unrelated to the task. In such cases, the researcher would ask a participant if he/she needed assistance. They were also assisted when they sought the assistance of the researcher by communicating with him through the microphones in the testing rooms. There were only two participants who completed the tasks with zero assisted recoveries and they also recorded shorter times to complete the tasks.

7.3.3.6 Unassisted recoveries

There were six participants who had unassisted recoveries. The average frequency for unassisted recovery was therefore 0.8. In most instances of participants being stuck, the errors were to do with navigation and orientation, that is, they did not know where they were in the system.

7.3.3.7 Number of commands used

Doing the UT tasks were required participants to use mouse clicks to access the commands. This was intentional on the part of the system designer, so as to reduce errors that arise when one types a wrong command. This approach of mouse-clicking as the main medium of accessing commands is in line with the style of most windows-based systems. Figure 7.8 gives a comparison between the time taken to complete the tasks and the number of commands used.

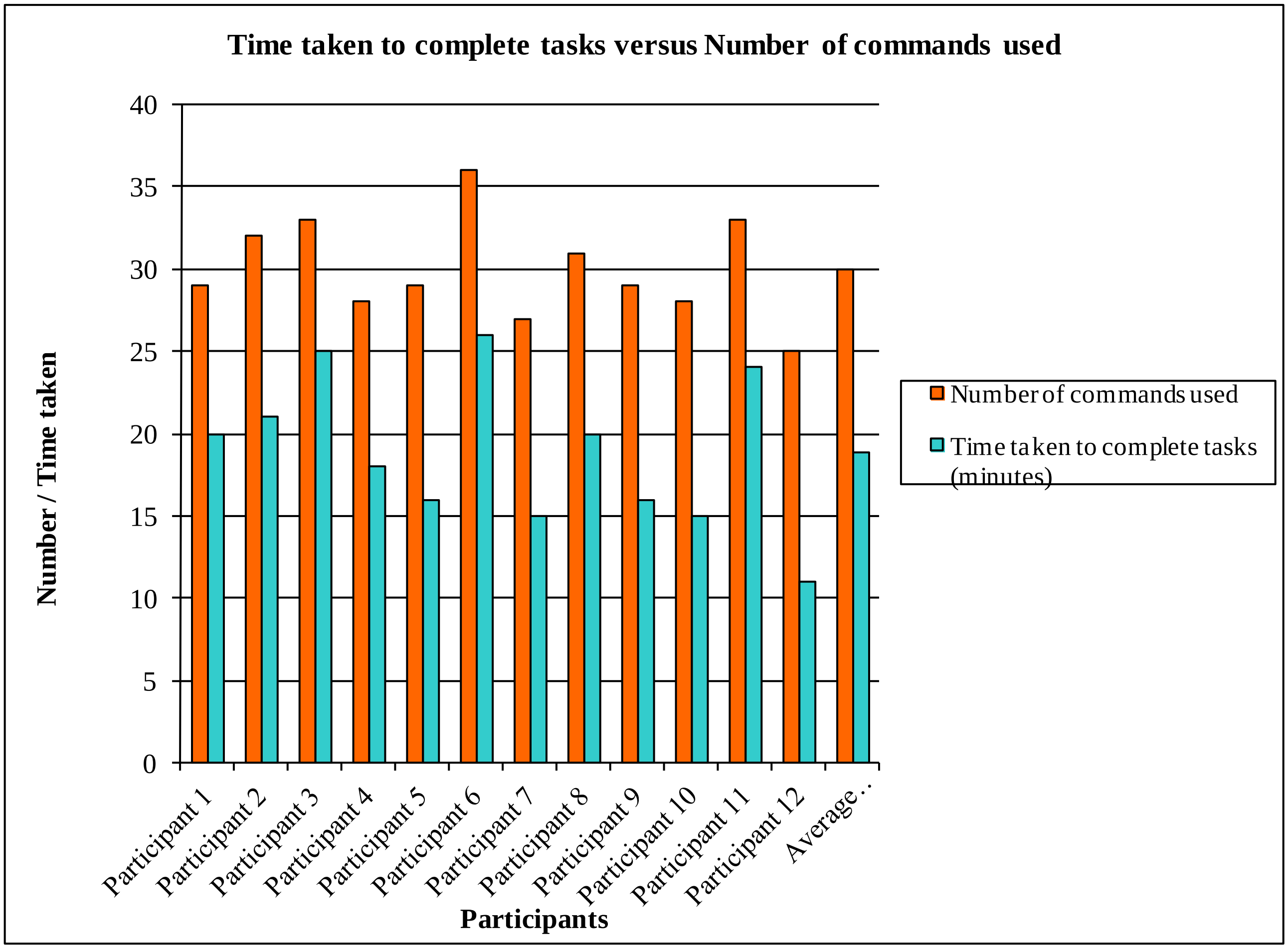

Figure 7.8: Comparison of time taken to complete tasks and number of commands used.

From Figure 7.8, it can be seen that the average number of commands (mouse clicks) used by participants is 30, while the average time taken to complete the tasks is 18.9 minutes. The results also show that the three participants who took longest to complete the tasks used the most commands. The number of commands that they used was increased when they were guided back from the user errors. There were seven participants who used less than the average number of mouse clicks. Six of those seven also had lower than average for the time taken to complete the tasks.

For all the participants, there were a higher number of mouse clicks when attempting the *exercise* than when going through the *learning* part of a session. For the exercise, one needed to click when moving to the next question while for the *learning* part, some of the times was spent just reading and listening.

7.3.3.8 Number of error messages

Table 7.10 (in Section 7.3.3.2) shows that there were only two participants who encountered error messages. This was poor compared to the total of 39 errors made by all participants. From these cases, it was observed that the system rarely has error messages for its interfaces. This is an unfortunate situation that is likely to leave learners stuck for a longer period of time without knowing what is required. The system should be improved in that aspect, so that when a user makes a mistake, there is an associated error message

7.3.4 Responses to questionnaire after usability testing sessions

Table 7.12 presents an analysis of the participants' responses to the questionnaire that they completed at the end of the testing sessions, to complement the recordings of the testing sessions. Some of the evaluation statements related to the impression of Instap1E4B. From the responses in Table 7.12, the overall mean rating was 2.5 (on a Likert scale of 1 to 5), indicating that the participants found the system's usability acceptable, but were not fully convinced. (See responses to Statements 1, 6 and 8, which are highly related to usability aspects.) The participants were not affirmative about the system's menu items and felt that they are not organised (Statement 7).

They tended to prefer classroom learning to working with *Instap!E4B*, as shown by responses to Statement 10 with a poor Likert rating of 3.4. Five participants had reservations about the ease of understanding the functions of the menu items as shown in Statement 4. A similar number of participants felt that the system's interface did not guide them well (Statement 5).

Table 7.12: Rating of statements after usability test

No.	Evaluation statement in post-questionnaire	Strongly agree (Likert 1) Count	Agree (Likert 2) Count	Not sure (Likert 3) Count	Disagree (Likert 4) Count	Strongly disagree (Likert 5) Count	Total Count	Mean rating [Likert]
1	It is easy to explore the different parts of the system (*Instap! E4B*).		9		3		12	2.5
2	Time allocated for the tasks was sufficient.	7	5				12	1.4
3	The online Help facility is useful.	2	6	2	2		12	2.3
4	It is easy to understand the functions of the menu items.	2	5		5		12	2.7
5	The interface guides the users well (does not mislead users).	2	5	1	3	1	12	2.7
6	The functions that I expected to find in the menu items were present.	1	7	1	3		12	2.5
7	This educational tutorial has well-organised menu items.	2	4	2	3	1	12	2.8
8	It is easy to know where I am in the system (navigation and orientation).	2	5	2	3		12	2.5
9	The system can supplement classroom learning of English language for Business.	2	3	3	3	1	12	2.8
10	I would prefer the system to classroom when learning English language for Business.	1	3		6	2	12	3.4
11	The system supports learning.	2	8		1	1	12	2.3

12	I was comfortable with speaking as I did the tasks.	3	6		3		12	2.3
13	I could have done differently if I did the tasks outside the laboratory.	6	2	1	2	1	12	2.2
14	The laboratory provides a suitable environment for these tasks.	3	6	2	1		12	2.1
	Mean ratings	**21%**	**44%**	**8%**	**23%**	**4%**		**2.5**

The questionnaire also investigated how participants felt about the experience of going through usability testing sessions. They agreed that the time allocated for the testing session was sufficient (Statement 2), allocating it a good mean Likert scale rating of 1.4. Nine participants were comfortable with speaking out loud as they worked on the usability testing tasks (Statement 12). This verbalisation of one's thinking process is called think-aloud (Dix *et al*., 2004; Preece *et al*., 2007). These comments assisted the researcher in understanding the intention of the participants during the sessions and were also useful when re-viewing the sessions in the analysis of the video-audio clips. If the sessions had been conducted outside a laboratory setting, eight participants felt that they might have performed differently. They would have worked more informally and less accurately. It is also encouraging that nine participants agreed that the laboratory setting was appropriate for the sessions. This had a Likert scale rating of 2.1 which is good. They were not put off by the presence of the researcher and this goes a long way to confirm the reliability of the test results.

7.3.5 Usability problems identified from the usability testing sessions

This section outlines the problems experienced by participants in the UT sessions. Some problems emerged from controlled observations of the sessions; others emerged from the questionnaire administered in the post-session debriefing; while other problems came from a combination of the observations and the questionnaire.

Table 7.13 consolidates the usability problems that were noted in live observation and in reviewing the video recordings of testing sessions. These problems were phrased by the researcher following his findings. The *frequency* column indicates the number of users who encountered that specific problem and the *percentage* column shows the percentage of users who encountered the problem. The problems are ranked from the highest to the lowest frequency. The table shows that the most frequently encountered problem was poor orientation and navigation (Problem 1). The least was the need for clues to guide learners when stuck (Problem 6).

Over ninety percent (91.7%) of the participants found that the interface menu items were not well organised. This was due to poor system orientation and navigation (as indicated by Problem 1 in Table 7.13). This was supported by their responses during debriefing at the end of usability testing sessions.

Table 7.13: Problems identified from the sessions in the usability testing

No.	**Problems**	**Frequency**	**Percentage (%)**
1	There is a need to improve navigation and orientation in the system.	11	91.7
2	Poor organisation of menu items.	10	83.3
3	Even though some interfaces have sound (audio) facilities, there is need for the same in major interfaces, if not all.	8	66.7
4	Absence of commonly found functions in the menu, some menu items are different from those of other generic systems.	7	58.3
5	The participants looked a bit nervous for the first two minutes of a session.	4	33.3
6	There is a need to include clues to guide participants when stuck, for them to be able to find their way out.	3	25.0
7	Lack of error messages.	10	83.3

A further issue was that, on average, the participants paused for about half a minute after reading the task sheet before commencing each task. They took time to grasp the directions before proceeding, indicating the importance of tasks being precise and explicit on what is expected. Participants continued to refer to the task list as they continued throughout the sessions.

The intense observation by the researcher during the usability testing helped to identify strengths and weaknesses of the system as discussed in Section 7.3.2. It was during observation that the researcher noted incidences when a participant was stuck and the length of time they took to recover from each error.

Table 7.14 provides information obtained from the post-session questionnaire. It comprises a list of statements extracted from Table 7.12, due to their Likert scale ratings of 2.5 and above. They are thus likely sources of usability problems, since the responses to them tended towards ‘Disagree‘. These are aspects that could hinder effective use of *Instap!E4B.* They were Statements 4, 5, 7, 9 and 10.

Table 7.14: Statements with poor ratings from usability testing questionnaire

No.	**Evaluation statements** (that are associated with possible usability problems)	**Mean rating [Likert]**
4	It is easy to understand the functions of the menu items.	2.7
5	The interface guides the users well (does not mislead users).	2.7
7	This educational tutorial has well-organised menu items.	2.8
9	The system can supplement classroom learning of English language for Business.	2.8
10	I would prefer the system to classroom when learning English language for Business.	3.4

Regarding Statement 10, in Table 7.14, with the worst rating in the table, participants gave the system poor ratings mainly because of poor navigation and disorganised menu items. Another reason for that rating was lack of currency of the contents. The participants’ responses also showed that that they were not keen on supplementing classroom learning with this system (Statement 9). Lack of currency is an issue that arises when a system or lesson is on a CD and cannot be updated in a dynamic way, as can be done with content on the Internet. All these issues are problems that should be attended to by the designers of *Instap!E4B.*

Table 7.15 presents a summary of aspects that the participants liked least. These aspects mainly covered organisation of the system’s interface and navigation. This data was obtained from analysis of a qualitative open-ended question in the post-session questionnaire.

Table 7.15: Aspects that participants liked least

Aspects participants liked least	**Frequency**	**Percentage (%)**
The interface is not well organised, especially the buttons.	10	83
Poor navigation paths.	11	91
Buttons are not appropriate for adult learners - they resemble children's games.	4	33
Poorly defined buttons have an adverse affect on navigation.	4	33

During the debriefing session at the end of the testing session, the participants indicated the need to address the following:

- Simplify the process of erasing a previous answer while doing exercises, so as to enter a replacement.
- There is a need for closer correspondence between the lessons and the questions, and
- There should be shortcuts for expert users, e.g. right clicking.

In this section, Tables 7.13 and 7.14 mainly answered Research Question 2, the sub-question that is aimed at determining:

> *What usability and learning problems in Instap!E4B can be identified from evaluation by usability testing?*

The section has therefore achieved one of the objectives of this study.

7.3.6 Positive aspects of *Instap!E4B*

The following aspects, presented in Table 7.16, are those that participants liked most about *Instap!E4B*. The data was obtained from analysis of qualitative open-ended questions in the post-session questionnaire.

Table 7.16: Aspects that participants liked most

Positive aspect	Frequency	Percentage (%)
Help facility for grammatical topics.	4	33
Ease of resetting fields.	4	33
Availability of the audio option in some instances that provides an additional interface mode.	8	67
The instant system feedbacks to responses while users are doing exercises.	5	42

Of the above, the most popular aspect was the audio interface. Eight participants described it as the aspect they liked most. Feedback during the exercises returned an impressive rating of 42%. A third of the participants liked the grammatical topics in the Help facility and the ease of resetting fields during exercises. Some participants felt that the Help facility could be improved to adequately cover areas outside grammatical topics.

7.3.7 Discussion of usability testing as a UEM

The following are some of the major findings regarding the use of usability testing as a UEM. As mentioned earlier, these are based on direct observation, on debriefing and on viewing video recordings of the sessions.

- It became evident to the researcher that one of the strengths of usability testing as a UEM is the fact that it involves close and meticulous observation of users' interaction with the system under investigation, as well as issues related to learning with *Instap!E4B.*

- The above was further strengthened by the ability to re-view sessions on the video recordings. These video and audio records made it possible to iteratively analyse the findings. It must, however, be acknowledged that analysing observation data is a time-consuming process.

- Usability testing proved to be more complex than many other UEMs, in terms of the sophisticated technology and resources that were required to be mobilised to conduct the sessions. This, however, had major advantages since the data collected in this way includes aspects and intricacies that might not have been possible with learner surveys. As a UNISA student, the researcher was fortunate to have access without cost to the facilities of HCI laboratory.

- Usability testing provides both quantitative and qualitative data. The problems that were identified, showed *what* aspects participants did not like about the system, and the debriefing sessions clarified *why* they did not like them. The usability testing methodology includes two data collection methods, observation and questionnaires/interviews in the post-session debriefing.

- Usability testing established that when participants got stuck during sessions, there was the likelihood either that they were lost in hyperspace or that the system lacked clarity.

The next section presents a comparison of the results from the two UEMs. This comparison informs the discussion in Section 7.6 which is about the effectiveness of the two UEMs to evaluate a learning system.

7.4 Comparison of usability testing and learner survey results

This study, as mentioned in Section 7.1 relates to usability evaluations of *Instap!E4B* using the two identified UEMs. This section intends to answer the first part of Research Question 3:

> *How do the results and the findings of the two usability evaluation methods (UEMs) compare?*

The comparison of the results of the two methods contributes to the goals of the study to determine the effectiveness of the UEMs' in investigating the usability of an e-learning tutorial (see Section 1.3). The use of the two UEMs in combination enhanced the reliability of the study, and provided useful information regarding the usability problems in the target e-learning tutorial, *Instap!E4B*. In determining the effectiveness of using two methods to evaluate the e-learning tutorial, the findings also contribute to meta-evaluative knowledge regarding the evaluation of e-learning. Section 7.2 presented the findings of the *user survey* and discussed the strengths and weaknesses of this UEM. In Section 7.3, the strengths and weaknesses of *usability testing* were discussed alongside the analysis of the data from that UEM. A comparison of the problems found by the two methods, is presented in the subsections that follow.

7.4.1 Common and unique findings of the UEMs

Using data from the two usability evaluation studies, areas needing improvement as experienced by participants, were identified and shown in Table 7.17. The magnitude of each usability problem is rated as *Minor, Medium* or *Major*.

1. *Minor* implies that the system is acceptable for now without largely impacting learning, but the problem should be addressed in future releases of the software.
2. *Medium* implies that if the problem is not minor. It should be addressed in the next release, so that the usability problem no longer impedes learning.
3. *Major* implies that meaningful e-learning is affected unless the problem is addressed as a matter of priority. This is a problem that qualifies to be addressed by releasing a software patch (immediate fix) to users of the system for the purpose of updating the application.

The last column of Table 7.17 indicates the UEM/s that identified each problem.

Table 7.17: Usability problems identified using the two UEMs

No.	Areas requiring improvement (Usability problems)	Extent of the usability problem	UEM that identified the problem
	Usability problems identified by both UEMs		
1	Poorly organised menu items.	Major	Usability testing; learner survey.
2	Inadequacy of the built-in dictionary.	Major	Usability testing; learner survey
3	Help facility interfaces are incomplete e.g. lack of drop-down menus.	Major	Usability testing; learner survey.
4	The content of the system is not current.	Major	Usability testing; learner survey.
5	Lack of error messages in many cases. These would guide users towards recovery on encountering errors/difficulties.	Major	Usability testing; learner survey.
6	Compared to similar systems, the toolbars have fewer interface features.	Medium	Usability testing; learner survey.
7	Lack of audio interface for some learning sessions.	Medium	Usability testing; learner survey.
8	Lack of confirmation on completion of tasks.	Minor	Usability testing; learner survey.
	Usability problems identified by questionnaire survey only		
9	No minimise button for the windows.	Medium	Learner survey.
10	Lack of example questions with answers. These should be presented before users attempt exercises.	Medium	Learner survey.
11	Lack of information regarding whether users should click or double click on interactive menu items.	Minor	Learner survey.
	Usability problems identified by usability testing only		
12	Unnumbered questions.	Major	Usability testing;

13	Lack of clarity in some questions in the exercises.	Major	Usability testing.
14	Poor correspondence between the lessons and the questions.	Major	Usability testing.
15	Difficulty in erasing a previous answer to make a replacement, while doing exercises.	Major	Usability testing.
16	Lack of shortcuts for expert users, e.g. right clicking.	Medium	Usability testing.

In Table 7.17, there are a number of areas that both of the UEMs identified as being usability problems. The number of problems identified was 16. Eight problems were common to both UEMS; three were unique to the survey; and five were unique to usability testing.

- Identified by both UEMs: 8 problems – 5 Major; 2 Medium; 1 Minor.
- Identified by questionnaire only: 3 problems – 2 Medium; 1 Minor.
- Identified by UT only: 5 problems – 4 Major; 1 Medium.

Table 7.17 shows that usability testing on its own identified more problems (5) than the questionnaire survey on its own (3). Furthermore, of the five identified by UT, four were major, indicating that UT on its own was more effective than the questionnaire on its own. Table 7.17 also shows that using the two methods together *confirms* certain findings and provides other results that *complement* each other. The use of two methods in combination is thus an effective way of evaluating an e-learning system.

Although the problems identified are usability problems and not instructional design problems as such, they are likely to impede learning since they affect user interaction with the learning functionality. As stated clearly in this dissertation, identification of problems that affect learning and that hinder users from achieving the learning goals, is as important as finding usability problems. Statements 2, 4, 5, 12, 13 and 15 are problems that impact directly on the learning process. Their severity has been rated as *Major* to underscore the need to address them as soon as possible. Statement 3 has been rated as a *Major* usability problem because the use of the Help facility should apply across the entire system. Statements 6, 7, 9, 10 and 16 were rated as *Medium* usability problems. Even though they are usability problems that are related to the process of learning, the learner may continue learning for some time before they need to be addressed. Statements 8 and 11 were rated as *Minor* because of their low impact on learning. For instance Statement 11 relates to learners not being informed when they should click or double-click. This is a minor usability problem because if a user clicks and there is no response, then double clicking should be the next option.

From the nature of the problems presented in Table 7.17, it is evident that most of the usability problems within *Instap!E4B* can be resolved through redesigning the interface and updating the learning content. Table 7.17 also serves as a summary of the answer to Research Question 2:

> *What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?*

7.4.2 Likert scale ratings: similar results from the two UEMs

It is of note that there were cases in which the two UEMs yielded almost identical Likert scale ratings. These occurred in the context of the questionnaire completed by UT participants after their sessions in the laboratory and in responses to criteria in the main questionnaire in the user survey. Such results confirm the integrity and validity of the results, particularly when it is considered that the two studies were conducted with different samples of participants. This is an important finding for identifying problems in a learning system and indicates the worth of the dual approach in which the two sets of data confirm certain findings.

Table 7.18 presents the evaluation criteria that were rated similarly in the two questionnaires and that yielded virtually identical Likert scale ratings in the two studies. The criteria were not worded in exactly these terms in the original questionnaires, but are phrased as such in the table to simply presentation of findings.

Table 7.18: Comparison of results with almost identical Likert scale ratings

No.	Statement	Rating from usability testing	Rating from learner survey	Average rating
1	The online Help facility is useful.	2.3	2.3	2.3
2	It is easy to understand the functions of the menu items.	2.7	2.7	2.7
3	The interface guides the users well (does not mislead users).	2.7	2.9	2.8
4	The functions that I expected to find in the menu items were present.	2.5	2.6	2.55
5	This educational tutorial has well-organised menu items.	2.8	2.9	2.85
6	It is easy to know where I am in the system (navigation and orientation).	2.5	2.4	2.45
7	The system can supplement classroom learning of English language for Business.	2.8	2.7	2.75

Two statements returned identical Likert scale ratings for the two UEMs. These were the usefulness of the Help facility that had a rating of 2.3, and the ease of understanding menu items, which had Likert rating of 2.7. For the organisation of menu items in the tutorial, the two UEMs returned Likert ratings of 2.8 and 2.9 respectively. These high ratings indicate negativity, since they emerged from several selections of the ‘disagree’ options. This calls for re-organisation of the menu items to address existing usability problems.

The qualitative nature of observation during usability testing enabled the researcher to ascertain when participants were stuck and to understand why they were stuck. In some cases this occurred due to the lack of a site map to help them find their way in the system. This is a strength of usability testing as a UEM when compared to user surveys where there is no observation of users working with a system. Additionally, the participants indicated that there was inadequate correspondence between lessons and exercises. This could discourage learners from attempting further learning sessions.

7.4.3 Likert scale ratings: varying results from the two UEMs

In other cases, the two UEMs yielded different results for similar criteria. Different reasons may have contributed to these variations. Table 7.19 presents evaluation statements that produced varying Likert scale ratings for participants' responses.

Table 7.19: Comparison of results with varying Likert scale ratings

No.	Statement	Rating from usability testing	Rating from learner survey	Average rating
1	It is easy to explore the different parts of the system (*Instap!E4B*).	2.5	2.8	2.65
2	I would prefer the system to classroom when learning English language for Business.	3.4	2.6	3.0
3	The system supports learning.	2.3	3.5	2.9

Table 7.19 shows that in two Statements (1 and 3) the learner survey returned responses with higher Likert ratings (that indicate negativity) than the ones for usability testing. Different factors that could have led to the variation in responses include:

- The type of environment in which the evaluations occurred,
- Number of participants in each study, and
- The context in which participants responded to the evaluation statements.

In Statement 2, usability testing had a higher Likert scale rating. The most important factor that could have influenced this rating is the controlled environment that resembled a classroom more than the environment of the questionnaire survey which was the home or workplace of the participant. Usability testing, being conducted in a controlled environment as discussed in Section 3.4.3, increases reliability as opposed to the learner survey. For the context in which participants responded to the evaluation statements, the usability testing provided a uniform and controlled environment (usability laboratory) which was the same for all participants. The pre-defined tasks further contributed to a uniform experience. Some participants of the learner survey, however, completed the questionnaires at different times over a two week period. This could explain why learner surveys returned varying results in some instances. The number of participants may also influence the results when computing the average for a given response. There were twelve participants in the usability testing compared to fifty for the learner survey. In some cases, use of more participants is likely to stabilise the range of the responses and lead to greater accuracy.

In this study, Research Question 3 asked:

> *How effective is the use of more than evaluation method to identify learning and usability problems in an interactive CD-based tutorial?*

Sections 7.4.1, 7.4.2 and 7.4.3 have answered the first part of Research Question 3:

> *How do the results and the findings of the two usability evaluation methods (UEMs) compare?*

The information in these sections showed how the two UEMs gave very similar results with only a few instances of variations. The second part of Research Question 3 is:

> *Does the dual approach to evaluation enrich the findings?*

The data in the Sections 7.4.1, 7.4.2 and 7.4.3 confirm that the findings were enriched by using the two UEMs, thereby answering. This is addressed further in Section 7.5.

7.5 Effectiveness of using two UEMs for usability evaluation

The use of two UEMs for a dual approach to the usability evaluation of an interactive e-learning CD-based tutorial, was effective. This enriched the findings, as shown in Tables 7.18 and 7.19. Using the two UEMs, the high number of participants in the two main studies together, confirmed certain usability problems by repeated identification. This is important for reliability of the results. The comparison presented in Table 7.18 shows that half (eight) of the problems were identified by both methods. Of the other eight, five were identified by usability testing only and three by the questionnaire survey only, i.e. one UEM identified problems that the other did not, showing the complementary value of using two UEMs in combination. Table 7.17 presents vital information that, if implemented in revisions, can play a major role in addressing usability problems in *Instap!E4B*.

The final part of Research Question 3 asks:

> *Do the findings contribute to meta-evaluative knowledge in the context of usability evaluation of e-learning?*

Towards addressing this, the following was noted:

- The number of participants in the usability testing, namely 12, was appropriate. It appears that a range of 8 to 12 participants is a good number for evaluation by usability testing. This is in line with Hwang and Salvendy (2010) recommendation that there should be 8 to12 participants for usability testing (see Section 6.5).

- Conducting a pilot study is necessary for correcting and refining the research instruments to be used in a main study. This was done in the case of both the usability testing and the user survey. The improvements in the tasks and questions contributed to obtaining valid results in the main studies. This view is in line with Olivier (2009) who observes that piloting a study helps to minimise inadequacies with the study tool.

- Observation and recording of data during usability testing sessions, as well as the personal communication with participants, captures certain qualitative data that would not be possible from user surveys. This enables a researcher, as mentioned in Section 3.4.2, to understand the participants' interaction with a system in its natural setting (Preece *et al*., 2007). Depending on the intended objectives, the type of data required, should influence the choice of UEM.

- An appropriate sample size is an important factor in obtaining accurate results. This is in line with the recommendation that testing be conducted using a small sample of the real users (Mouton, 2008; Olivier, 2009; Perfetti, 2010).

- The use of two different methods of evaluating a system is better than one on its own. There is the element of confirmation when major problems are identified by both UEMs, but on the other hand there is a complementary role when one method identifies a problem, although the other one did not.

- The findings of the two UEMs have shown that the evaluation of e-learning systems has a different usability evaluation emphasis from other systems. The evaluation of e-learning systems focuses on addressing interactions that assist the learners to achieve the learning objectives. This finding is in line with the standpoints by Masemola and De Villiers (2006) in Section 3.3.1 and Mayes and Fowler (1999) in Section 2.4.1 in their studies on evaluation of educational software and e-learning.

From the discussions in Section 7.3.6, it was found that UT was effective in identifying usability problems that required empirical measures such as time taken to recover from errors. Section 7.2.8 showed that the learner survey, which was conducted in a non-controlled environment, was able to gather more data regarding how participants felt about the system. That section also showed the importance of a large number of participants for obtaining validity of the findings in the user questionnaire survey. It was also noted that whereas the learner survey merely showed the opinions of participants and what they liked most or least, UT could capture information about the reasons for their opinions. This was due to the researcher's direct involvement with participants. This capability to capture data regarding users' hands-on experience with a system, is an important advantage of usability testing.

7.6 Summary and conclusion

The *Instap!E4B*, as an application software for learning Business English, was evaluated by 88% of the intended participants for the survey and 100% of the participants for usability testing. The results of this study using the two UEMs were similar, although usability testing identified more problems that user survey. The chapter also took note of some areas with varying results and the possible reasons for such cases.

Data analysis determined that the use of two UEMs is effective for conducting usability evaluation of a stand-alone offline tutorial. They affirmed findings by identifying a common set of usability problems. The two UEMs further enriched the study by each producing some findings that the other did not identify. One of the major findings of the chapter is that if users get involved in user errors too often without assistance being readily available, the learning pace is likely to be impeded.

The success of this research was enhanced by the pilot studies that assisted in adjusting and refining the usability evaluation instruments as mentioned in Sections 7.2.1 and 7.3.1. In Section 7.2, the findings of the learner questionnaire survey were presented. Section 7.3 showed how usability testing can be used in a controlled environment and presented results that were important for identifying usability problems in *Instap!E4B*. Sections 7.2 and 7.3 presented valuable data in the form of tables and figures and also discussed the value of the two UEMs themselves at the end of each section respectively.

This data was then used to compared the results of the two UEMs and determine their effectiveness in usability evaluation. The main finding of this chapter as presented in Section 7.4 is that two different UEMs can yield certain very similar results that confirm findings and can also yield differing results that enrich the overall findings. It also showed, in Section 7.4.3 that, in cases where the results showed a large variation, then factors such the evaluation environment might have played a role. However, as discussed in Sections 7.3.6 and 7.5, usability testing has more strength in collecting empirical data. Section 7.5 pointed out that the use of two usability evaluation methods in combination is effective and explained why. The section made reference to Table 7.17 that presented the identified usability problems set from comparison of the two UEMs' results.

The discussions presented in the whole chapter were important in answering Research Questions 2 and 3 as shown in Section 1.4 and 6.3. This chapter has established the basis for Chapter 8 which presents the conclusion and recommendations for the study.

CHAPTER 8:

Conclusions and recommendations

8.1 Introduction

This chapter consolidates this research in Section 8.2 by overviewing the answers obtained to the research questions. In Section 8.3 areas are suggested that need future research as a follow-up to this study. Section 8.4 highlights the contributions of this research and makes some recommendations. The entire study is concluded in Section 8.5.

8.2 Answers to the research questions

It is important to ensure that the study has answered the Research Questions presented in Section 1.4:

1. What are appropriate criteria for evaluating an e-learning tutorial?

2. What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on *Instap!E4B*?
   - What usability and learning problems in *Instap!E4B* can be identified from evaluation by a user questionnaire survey?
   - What usability and learning problems in *Instap!E4B* can be identified from evaluation by usability testing?

3. How effective is the use of more than one evaluation method to identify learning and usability problems in an interactive CD-based e-learning tutorial?

- How do the results and the findings of the two usability evaluation methods (UEMs) compare?
- Does the dual approach to evaluation enrich the findings?
- Do the findings contribute to meta-evaluative knowledge in the context of usability evaluation of e-learning?

The first question, *What are appropriate criteria for evaluating an e-learning tutorial?*, was addressed in Chapters 2 and 3, where literature on learning theories, e-learning and usability evaluation of e-learning systems was considered. This was important for developing the actual criteria for usability evaluation that are presented in Chapter 4. Section 4.4 includes three tables of criteria that are appropriate for evaluating various forms and methodologies of e-learning. Section 4.5 follows on by extracting criteria from the preceding sections and synthesizing a framework of evaluation criteria specifically for this study. The criteria formed the foundation of the evaluation statements in the questionnaire and the basis of the UT tasks and metrics. The mappings of evaluation statements and usability testing tasks to related criteria are presented in Table 7.2 (Section 7.2.2) and Table 7.6 (Section 7.3.2) respectively.

It was important to understand the system and its interfaces before proceeding with the evaluations. For this reason, Chapter 5 discussed the target system, *Instap!E4B* and gave graphical representations of what the system entails. Chapter 6 then presented the research design which was important in guiding the two usability evaluation sessions. Chapter 6 also laid the basis for the reporting and analysis of results as presented in Chapter 7. The criteria presented in Chapter 4 were important for the design as set out in Chapter 6.

Question 2 is *What usability and learning problems can be identified from evaluation by usability testing and a user questionnaire survey in the case study conducted on Instap!E4B?*

It is followed by two sub-questions that focus, respectively, on the findings of the evaluations by the two UEMs, namely user questionnaire survey and usability testing. These two sub-questions are answered in Chapter 7, in Sections 7.2 and 7.3. In particular, Table 7.3 in Section 7.2.2 and 7.5 in Section 7.2.3 answered the sub-question regarding the user questionnaire survey by presenting the usability and learning problems identified in the learner survey. Table 7.13 and Table 7.14 in Section 7.3.5 present the usability and learning problems that were identified when using controlled usability testing in the HCI laboratory.

Question 3 investigated *How effective is the use of more than one evaluation method to identify learning and usability problems in an interactive CD-based e-learning tutorial?*

The question and its first two sub-questions were answered in Sections 7.4 by comparing the results and findings of the methods to find out whether the dual approach to evaluation enriched the findings.

Table 7.17 listed the problems identified by both of the UEMs and the problems identified by only one of the two. Eight problems were identified by both methods in common. Another eight problems were identified by only one of the two methods, with UT uniquely finding five problems and the survey finding three unique problems. This demonstrates that the dual approach to evaluation enriched the findings. Using two methods in combination emphasises the main problems, but also shows up problems that would not have been identified by using one UEM only. Each method has particular features and strengths, which are discussed in Section 7.2.8 for the user questionnaire survey and Section 7.3.7 for usability testing. It appears that, if only one method could be used, then usability testing is a superior method. It identified more problems than the survey and also found more of the major problems. However, it is an expensive method, which uses sophisticated technology and must be managed by trained facilitators.

Section 7.5 answered the final sub-question of Research Question 3 by indicating that the findings do contribute to meta-evaluative knowledge regarding usability evaluation in the context of e-learning. Various practical points were listed in Section 7.5 that should help researchers undertaking similar evaluation studies.

8.3 Future research

This study has identified the following areas for possible future research:

- A study of learners' achievement of the learning objectives for an e-learning tutorial, after its usability and learning problems have been addressed.
- Use of the synthesized sets of evaluation criteria in evaluating other forms and methodologies of e-learning applications, to investigate to what extent they are relevant and useful.
- A comparative study of usability and learning problems in offline interactive tutorials versus Web-based learning systems.
- This study was conducted using two UEMs with participants who are regular users of computers. It would be interesting to see how the use of participants who are novice users or have limited access to computers would impact on the findings.

The above-mentioned areas are not exhaustive but could contribute to the research domain that need pursuing in this field.

8.4 Contribution of the study and recommendations

The main contribution of this study relates to establishing the value of using two UEMS, instead of one, to evaluate an e-learning tutorial for its usability and support for learning. The use of two methods results in *confirmatory* findings and also in *complementary* findings. The results of this research recommend the use of more than one UEM for evaluating not only offline e-learning tutorials such as the one used as the target system, but other e-learning applications as well.

A secondary contribution is the generation by the researcher of the framework of evaluation criteria, which are transferable to other situations and could have value beyond this study.

An additional achievement of the study was conducting a usability evaluation of *Instap!E4B* which identified the usability problems in that system that should be addressed. Guided by Table 7.5, the study leads to recommendations regarding the design and features of the *Instap!E4B* e-learning software application. Some examples are:

- The need to update the contents of stand-alone offline systems to maintain currency and relevance,
- The requirement for feedback and error messages, and
- Participants appreciated the way the audio mode enhanced the learning of English for use in business, but an audio interface for all main interactions would be desirable. The audio mode should also have a disabling option.
- It would support the learning environment if a sitemap was provided to enable learners to always know where they were in a system. When learners lose orientation for considerable periods, they are likely to lose focus regarding the learning objectives.

8.5 Conclusion

This meta-evaluative study showed how the usability evaluation of e-learning systems is different from that of conventional task-based systems. Evaluation of e-learning applications should also address aspects that could hinder learning. The researcher synthesised and presented a framework of criteria that guided the usability evaluation studies using two UEMs. These criteria assisted in establishing the usability testing tasks and metrics for the study, as well as informing the evaluation statements in the user questionnaire.

In addition to addressing the issue of using two UEMs to evaluate an e-learning tutorial, the study showed that technology should support the learning objectives and not cause learners to focus on understanding the underlying technologies. Findings showed that the practical value of using two UEMS is enhancement of the results of the usability evaluations and the identification of more problems than would have emerged from evaluation by only one method. The use of more than one method also enhances credibility and reliability of the findings.

Appendices

Appendix A: Study instruments and related documents

Appendix A-I: Permission from the designer-developer of *Instap!E4B*

From: Lut Baten [Lut.Baten@ilt.kuleuven.be]
Sent: 08 June 2012 05:47 PM
To: De Villiers, Ruth
Subject: permission MULTITAAL

Dear Prof de Villiers

It is with pleasure that I grant your MSc student, Mr J. Nyang'or, full permission to use MULTITAAL (*InStap E4B*) in his evaluation studies.

I am very eager to learn about the progress.

Kind regards,
Lut Baten (prof.dr.)
ILT KULeuven
Dekenstraat 6
B 3000 Leuven
00 32 16 32 56 87

Appendix A-II: Consent form

Consent form

Intention of the consent

We require your informed consent for participation in this usability testing session.

Assurance therefore is given that the information collected will be used solely for the purpose of my studies in this MSc (Information Systems) course and related academic purposes. In a case where the identity has to be revealed, pseudo names/codes will be used to conceal a participants' identity.

You are therefore kindly requested to sign below.

Participant's consent

I, ______________________________, hereby willingly give consent to participate in a usability evaluation of *Instap!E4B*. I agree that information can be collected and used only for the above stated purposes.

Signature: __________________________________

Date: ____________________________________

Appendix A-III: Questionnaire

<u>User (learner) survey Questionnaire for *Instap!E4B*</u>

You have been using the above named system for at least a week to learn Business English. Based on your interaction so far with this system, kindly give your honest opinion to the following statements. Your input will be highly appreciated and will go a long way towards the success of this study. I thank you.

Indicate appropriately regarding your opinion about the following (use tick).

No.	**Statement**	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**Strongly disagree**
	General interface design					
1	The navigation links are readily available and visible throughout the learning sessions.					
2	The name of the system is appropriate.					
3	The system's contents are interlinked (without dead ends).					
4	There are similarities between this system and others that I have come across.					

5	The system enables me to control the pace of learning.					
6	This system allows me to customise it to support my personal learning needs.					
7	The section for frequently asked questions (faq) is useful.					
8	I would prefer using *Instap!E4B* to classroom teaching when learning the English language for Business use.					
9	The online Help facility is useful.					
10	The system motivates me to learn.					
11	I feel encouraged to participate.					
12	The graphical presentations (icons) are easy to interpret.					
	System's interaction					
13	The home page of the system opens quickly.					
14	It is easy to understand the functions of the menu items.					
15	The functions that I expect to find in the menu items are present.					

16	The menu items of the system are well organised.					
17	*Instap!E4B* is highly interactive.					
18	I need not recall the system interface during learning sessions.					
	Learner-centred instructional design					
19	There is a well-designed feedback mechanism within the system.					
20	I am able to search for content that I cannot initially find easily.					
21	This system engages me.					
22	The system provides the learning contents in a consistent manner.					
23	Compared to books, the system has up-to-date contents.					
24	The learning goals and objectives are made clear within the system.					
25	The learning content is current and accurate.					
26	The learning contents are presented in a way that supports learning.					

27	The animations aid learning.					
28	The audio interface (voice) improves learning.					
29	This system presents the content in small understandable chunks.					
30	The system's content is relevant for learning English for business.					
31	The learning activities enable me to practise the learnt skills.					
32	*Instap!E4B* supports different approaches to learning.					
33	The system has flexibility in addressing needs of different learners.					
34	*Instap!E4B* supports deep learning.					
35	The fact that learning materials are provided on multiple windows, supports learning.					
	System’s navigation and orientation					
36	It is easy to explore the different parts of *Instap!E4B*.					
37	It is easy to get back to the home page.					

38	The system's navigation setup enables me to access different contents easily.					
39	There are different ways of accessing the functions of *Instap!E4B.*					
40	I generally find it easy to use the system.					
41	It is easy to know where I am in the system.					
42	*Instap E4B* can supplement classroom learning of English language for Business.					
43	The learning tasks have tolerance for user errors that are related to learning, i.e. cognitive errors.					
44	*Instap E4B* supports me when I make usability errors.					

Does the system provide the content in different languages? (Yes / No).
Do you feel that you successfully completed all the tasks on the task sheet? (Yes / No).

Would you recommend to others to use the system for learning Business English? (Yes / No).

What did you like most when using the system?

………

What did you like least when using the system?

……………………………………………………………………………… …………………………………………………………

List any three areas that you would suggest be changed in this application?

……..

Please give any comments and/or suggestions about the system?

……………………………………………………………………………..

Appendix A-IV: Usability testing task sheet

Usability tasks for *Instap!E4B*

Please remember to speak aloud as you do the tasks

Task 1

1.0 From the main screen,

- Explore the buttons on both the top and bottom toolbars without clicking.

1.1 On completing, the above,

- Click the "Help" button ("Explanation about the screen"). You may take some two to three minutes to read the default screen.
- On completing, do **NOT** close that screen.

1.4 While on Help screen,

- Click on "Index" tab then from the menu select "Lesson overview".
- Take some time to read the screen content.

1.5After reading the screen content,

- Close the "Help" screen to go back to the main screen.

Task 2

2.3 On the main screen,

- Go to (select) the chapter on "Organisation".
- Making use of the "Listen" button, study the chapter's section on "Japan feels the heat of competition".
- Do **NOT** close the screen.

2.4 Attempt the exercise about the chapter as guided below:

- Select “Practice” from the bottom toolbar,
- Under “Subject” menu, select the option for “Grammar”
- Do the first TWO exercises by clicking on the “Do the exercise” button at the bottom left corner of the screen.

END!

Questions used after usability testing session

As part of usability testing, this brief questionnaire is intended to get an understanding of your opinion about this software, the usability evaluation of which you have participated in. The information that you provide is confidential and used only for the purposes indicated in the signed consent form at the beginning of the session.

Indicate appropriately your opinion about the following (use a tick).

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**	**Not sure**
It is easy to explore the different parts of the system (Instap B4E).					
It is easy to understand the functions of the menu items.					
The functions that I expected to find in the menu items were present.					
This education application software has well-organised menu items.					
It is easy to know where I am in the system (orientation and navigation).					
The system can supplement classroom learning of English language for Business.					
I would prefer the system to classroom when learning English language for Business.					
The online Help facility is useful.					
The system supports learning.					
It is easy to use the system.					

Do you feel that you successfully completed all the tasks on the task sheet? Yes / No

Would you recommend to others to use the system for learning Business English? Yes No

What did you like most when using the system?

…………………………………………………………………………………………

…………………………………………………………..…

What did you like least when using the system?

…………………………………………………………………………………………

…………………………………………………………..…

List any three areas that you would suggest to be changed in this application?

………………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

……………………………………………………………………………........

…………………………………………………………………………………

……………………………………………………………………………..

Please give any comments and/or suggestions?

……………………………………………………………………………………………

……………………………………………………………………………………………

Appendix A-V: Blank data collection Sheet

Task Number: ____________ Logged by: ____________________

Date: _____/___/______ Participant Number: ______

Time: (n^{th} minute)	Participant's action(s)
1^{st}	
2^{nd}	
3^{rd}	
4^{th}	
5^{th}	
6^{th}	
7^{th}	

Appendix B-I : Rating of general interface design statements

No.	Statement	Strongly agree {Likert 1} [%]	Agree {Likert 2} [%]	Not sure {Likert 3} [%]	Disagree {Likert 4} [%]	Strongly disagree {Likert 5} [%]	Total [%]	Mean rating [Likert]
1	The navigation links are readily available and visible throughout the learning sessions.		58	32	10		100	2.5
2	The name of the system is appropriate.	22	56	22			100	2.0
3	The system's contents are interlinked (without dead ends).	4	30	58	8		100	2.7
4	There are similarities between this system and others that I have come across.	34	50	16			100	1.8
5	The system enables me to control the pace of learning.	56	32	12			100	1.6
6	This system allows me to customise it to support my personal learning needs.		52	46	2		100	2.5
7	The section for frequently asked questions (faq) is useful.	16	40	42	2		100	2.3
8	I would prefer using *Instap!E4B* to classroom teaching when learning the English language for Business use.	10	26	56	8		100	2.6
9	The online Help facility is useful.	20	28	50	2		100	2.3
10	The system motivates me to learn.	2	8	40	50		100	3.4
11	I feel encouraged to participate.		24	30	46		100	3.2
12	The graphical presentations (icons) are easy to interpret.	12	26	20	42		100	2.9
	Mean ratings (%)	**15**	**36**	**35**	**14**	**0**	**100**	**2.5**

Appendix B-II: Rating of system's interaction statements

No.	Statement	Strongly agree {Likert 1} [%]	Agree {Likert 2} [%]	Not sure {Likert 3} [%]	Disagree {Likert 4} [%]	Strongly disagree {Likert 5} [%]	Total [%]	Mean rating [Likert]
1	The home page of the system opens quickly.	60	32	6	2		100	1.5
2	It is easy to understand the functions of the menu items.	14	24	40	22		100	2.7
3	The functions that I expect to find in the menu items are present.	6	40	38	16		100	2.6
4	The menu items of the system are well organised.	4	24	52	20		100	2.9
5	*Instap!E4B* is highly interactive.	2	32	50	2	14	100	2.9
6	I need not recall the system interface during learning sessions.		36	60	4		100	2.7
	Mean ratings (%)	**15**	**31**	**41**	**11**	**2**	**100**	**2.6**

Appendix B-III: Learner-centred instructional design statements

No.	Statement	Strongly agree {Likert 1} [%]	Agree {Likert 2} [%]	Not sure {Likert 3} [%]	Disagree {Likert 4} [%]	Strongly disagree {Likert 5} [%]	Total [%]	Mean rating [Likert]
1	There is a well-designed feedback mechanism within the system.	2	28	68	2		100	2.7
2	I am able to search for content that I cannot initially find easily.		40	42	18		100	2.8
3	This system engages me.		28	46	26		100	3.0
4	The system provides the learning contents in a consistent manner.		54	24	22		100	2.7
5	Compared to books, the system has current content.		50	16	20	14	100	3.0
6	The learning goals and objectives are made clear within the system.	6	60	24	8	2	100	2.4
7	The learning content is current and accurate.		44	22	22	12	100	3.0
8	The learning content is presented in a way that supports learning.	2	62	16	20		100	2.5
9	The animations aid learning.	68	18	10	4		100	1.5
10	The audio interface (voice) improves learning.	58	24	8	10		100	1.7
11	This system presents the content in small understandable chunks.		50	34	8	8	100	2.7

12	The system's content is relevant for learning English for Business.		56	24	18		100	2.6
13	The learning activities enable me to practise the learnt skills.		68	30	2		100	2.3
14	*Instap!E4B* supports different approaches to learning.	60	36	4			100	1.4
15	The system has flexibility in addressing needs of different learners.	2	30	24	44		100	3.1
16	*Instap!E4B* supports deep learning.		10	36	48	6	100	3.5
17	The fact that learning materials are provided on multiple windows, supports learning.	4	22	22	50	2	100	3.2
	Mean ratings (%)	**12**	**40**	**26**	**19**	**3**	100	**2.6**

Appendix B-IV:Rating of system's navigation and orientation statements

No.	Statement	Strongly agree {Likert 1} [%]	Agree {Likert 2} [%]	Not sure {Likert 3} [%]	Disagree {Likert 4} [%]	Strongly disagree {Likert 5} [%]	Total [%]	Mean rating [Likert]
1	It is easy to explore the different parts of *Instap!E4B.*	10	42	4	44		100	2.8
2	It is easy to get back to the home page.	4	30	28	30	8	100	3.0
3	The system's navigation setup enables me to access different contents easily.		64	30	6		100	2.4
4	There are different ways of accessing the functions of the *Instap!E4B.*	8	50	42			100	2.3
5	I generally find it easy to use the system.	6	46	32	16		100	2.6
6	It is easy to know where I am in the system.		48	40	12		100	2.6
7	*Instap!E4B* can supplement classroom learning of English language for Business.		50	34	14	2	100	2.7
8	The learning tasks have tolerance for user errors that are related to learning, i.e. cognitive errors.			52	40	8	100	3.6
9	*Instap!E4B* supports me when I make usability errors.		20	46	28	6	100	3.2
	Mean ratings (%)	**3**	**39**	**34**	**21**	**3**	100	**2.8**

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