USABILITY EVALUATION OF A WEB-BASED E-LEARNING APPLICATION: A STUDY OF TWO EVALUATION METHODS

by

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Abstract

Despite widespread use of web-based e-learning applications, insufficient attention is paid to their usability. There is a need to conduct evaluation using one or more of the various usability evaluation methods. Given that heuristic evaluation is known to be easy to use and cost effective, this study investigates the extent to which it can identify usability problems in a web-based e-learning application at a tertiary institution. In a comparative case study, heuristic evaluation by experts and survey evaluation among end users (learners) are conducted and the results of the two compared.

Following literature studies in e-learning – particularly web-based learning – and usability, the researcher generates an extensive set of criteria/heuristics and uses it in the two evaluations. The object of evaluation is a website for a 3rd year Information Systems course. The findings indicate a high correspondence between the results of the two evaluations, demonstrating that heuristic evaluation is an appropriate, effective and sufficient usability evaluation method, as well as relatively easy to conduct. It identified a high percentage of usability problems.

Key terms (in alphabetical order):
E-learning; evaluation criteria; heuristic evaluation; human-computer interaction; learning theory; questionnaire survey; usability evaluation; usability evaluation methods; Web-based learning; WebCT™

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Chapter 1: Introduction

1.1 Problem Statement

The use of the World Wide Web (WWW) as an information and communication technology has resulted in its widespread use as an educational medium of instruction for both distance and face-to-face learning (Tselios, Dimitracopoulou & Daskalaki, 2001:355; Vrasidas, 2004:911). Web-based e-learning applications are in high demand in educational institutions and in corporations that use them to train their employees (Feinberg & Murphy, 2000:353). This is because the Web permits the display of information in any medium, on any subject, in any order, at any time (Crossman, 1997:19; Jun, Gruenwald, Park & Hong, 2002:44). Consequently, cost-effective, relevant, personal and interactive learning can be delivered to learners, independent of time and location (Morrison, 2003:11).

Despite widespread use of web-based e-learning applications, very little has been done to critically examine their usability (Zaharias, 2006:1571). Usability features are frequently not considered in their development, mainly because many instructors and courseware developers are not trained to do so (Jones, Scanlon, Tosunoglu, Morris, Ross, Butcher & Greenberg, 1999:499) or lack the required technological skills (Vrasidas, 2004:911). For example, several higher education institutions in South Africa have developed web-based e-learning applications without consideration of usability (Van Greunen & Wesson, 2004:74). A further reason for not considering usability during such developments is because usability evaluation is usually difficult, time consuming and expensive (Kjeldskov, Skov & Stage, 2004:233).

The International Standards Organisation (ISO) defines usability as: “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context” (ISO, 1998). Usability is essential in order for web-based e-learning environments to be effective (Veldof, 2003:129). To ensure usability, usability evaluation should be performed during development (Granic, Glavinic & Stankov, 2004). Costabile, De Marsico, Lanzilotti, Plantamura and Roselli (2005:1) suggest that an evaluation of any educational software must consider both its pedagogic effectiveness and its usability.

A number of usability evaluation methods (UEMs) exist, such as analytical, expert heuristic evaluation, observational, survey and experimental evaluations (Brinck & Wood, 2002:406; Nielsen, 1995:377; Preece, 1993:109; Shneiderman & Plaisant, 2005:140). However, given that many instructors and developers are not familiar with any of them, as stated above, it is important that cost-effective, easy and efficient methods be used to evaluate the usability of applications and to determine usability problems (Hartson, Andre & Williges, 2003:169). Heuristic evaluation is a usability inspection technique where a small set of expert evaluators, guided by a set of recognised usability principles known as heuristics, determine whether a user interface conforms to these principles (Nielsen, 1994:26). Heuristic evaluation (HE) is the most widely used usability evaluation method for computer system interfaces, since it is effective, inexpensive, easy and fast to perform, and can result in major improvements to user interfaces (Belkhiter, Boulet, Baffoun & Dupuis, 2003:178-185; Blandford, Keith, Connell & Edwards, 2004:28; Karoulis & Pombortsis, 2003:93-97; Lindgaard, 2004).

This MSc dissertation describes the in-depth evaluation of a target application by two different methods and studies the findings in order to determine whether heuristic evaluation is sufficient for usability evaluation of web-based e-learning applications. If this is the case, it could then be recommended as a preferred method for usability evaluation of such applications. A website developed for a third-year Information Systems course at a higher education institution in South Africa was used as the object of evaluation. The main purpose of the study is to investigate and compare the results of the two evaluation methods, rather than the evaluation of the target system itself. However the evaluation findings could be used to improve the system, resulting in a secondary benefit.

1.2 Research Question

1.2.1 Primary research question

The main research question for this study is:

To what extent can heuristic evaluation identify usability problems of web-based e-learning applications in a tertiary institution?

1.2.2 Subquestions

The main research question gives rise to subquestions:

1. **What criteria are appropriate for usability evaluation of a web-based learning environment for a third-year Information Systems course in a tertiary education institution?**
2. **To what extent do the findings of heuristic evaluation by experts and survey evaluation among learners correspond?**

These questions will be answered in the course of the study.

1.3 Value of the Study

Primary beneficiaries of this study are the instructors and courseware developers of web-based e-learning applications. They can adapt the set of criteria synthesised in this study to conduct heuristic or other evaluations of the usability of their applications. Formative evaluations could be used during development to ensure that systems have appropriate usability features integrated into them. For websites already developed and operational, the set of criteria could contribute to those used to assess such sites for their usability, with a view to improving them. The criteria could also be used in summative evaluations and comparative studies when institutions are considering adoption of external applications or commercial products.

Further beneficiaries are the learners. An interface that is difficult to use impacts negatively on learning (Parlangeli, Marchingiani & Bagnara, 1999:38). Inclusion of sound usability features in learning applications should contribute to systems that support learners more effectively in their learning experiences.

Finally, if the approach of heuristic evaluation is used for usability evaluation of web-based e-learning applications, institutions that use such systems could benefit by enhanced quality of applications as well as by reducing the cost and time required to develop them, since HEs are inexpensive, easy and fast to perform, as stated in Section 1.1.

1.4 Scope of the Study

1.4.1 Domain of the study

This study spans two main areas – usability and e-learning. Existing literature and models are used as the foundations of this study, thus integrating the domains of human computer interaction (HCI) and education. This is done to set the context and create a general frame of reference for the rest of the study.

Firstly, background information is given on theories of learning and practical aspects of instructional design. E-learning theories and models are analysed, with particular emphasis on web-based learning.

Secondly, background information is given on usability in general. A number of usability evaluation methods are investigated and compared.

Thirdly, a set of criteria/heuristics (the terms will be used interchangeably) is derived, appropriate for evaluation of web-based e-learning applications. Heuristics suggested by Jakob Nielsen and Rolf Molich (Nielsen, 1994:29), are adopted and incorporated as a basis for the evaluations undertaken in this study. This base set is augmented by integration of criteria and heuristics from a wide variety of other sources, and structured into different categories, forming an extensive newly-synthesised set of criteria and sub-criteria in the form of evaluation statements.

Fourthly, a survey evaluation among learners, the end users, is conducted. This involves the use of two query techniques, namely, questionnaires and interviews.

Fifthly, a heuristic evaluation was conducted by expert evaluators, followed by a severity analysis done by the experts on the combined set of problems that emerged from the two evaluations.

Finally, in the context of web-based learning, usability problems identified in the target system by these two evaluation methods are presented and the two sets of results are compared.

1.4.2 Limitations and delimiters

The evaluation carried out in this study is conducted on an application called Info3Net (described in detail in Chapter 6). Info3Net is the website for Information Systems 3, for 3rd-level learners at Walter Sisulu University in South Africa. The Web course was designed using WebCT™, one of the commercial packages for designing and developing web-based e-learning applications.

Although computer-based learning environments can be set up for use as a supplement to face-to-face instruction or as a stand-alone tool for instruction (Jackson, 2004; Medby & Bjornestad, 2003), the context of use in this study is the former approach, also known as ‘blended learning’.

Though this study addresses both usability and learning, it will not try to determine the relationship between usability and learning, nor will it explicitly determine criteria that result in learning. However, aspects related to learning may be used in the derivation of usability

evaluation guidelines for web-based e-learning activities or may be included directly, since usability and learning are closely related (Masemola & De Villiers, 2006:189).
This study is limited to the investigation of how usability problems identified using the heuristic evaluation method compare with those identified by survey evaluations among end users.

1.4.3 Assumptions

The study assumes, firstly, that the users of the system have a fairly strong technological background, with at least one year of experience in working with computer applications. In actual fact, the learners in this case study have at least two years of IT studies at higher education level. Secondly, it is assumed that the learners have an adequate command of English, which is the medium of instruction. However, for most of them, English is their second language.

In this study, it is assumed that HE is inexpensive, easy and fast to perform when compared to other evaluation methods, as stated in Section 1.1. The issues of cost and time expended on the evaluations will not be investigated in this study.

1.5 Resources Consulted

A literature survey is conducted in the following areas, using books, journals articles, Internet articles and conference proceedings:

- Human computer interaction, particularly the areas of usability and usability evaluation methods; and
- Theory of learning and models of e-learning, particularly web-based learning.

A number of WebCT™ user manuals and articles on the Internet were utilised in the design and development of the Web course used for the study.

1.6 Research Design and Methodology

The aim of this research is to determine whether an existing and established general model, heuristic evaluation, when applied to web-based e-learning applications, is sufficient for identifying usability problems. This is investigated using Info3Net, a website for a third-year Information Systems course, as the object of evaluation. 'Sufficient', in this situation, means that it adequately identifies the problems that users themselves point out.

Firstly, criteria appropriate for usability evaluation of web-based e-learning applications are established. This is done using existing literature. The selected criteria are used in questionnaire and interview evaluations among the course learners, to determine the problems identified by real end users. The criteria are then used as heuristics in an expert heuristic evaluation of the target system. Finally, a study is undertaken of the extent to which the usability problems identified using heuristic evaluation compare with those identified by real end users.

1.6.1 Case study research

The main research method used in this study is a case study research, where the case is a particular course taught in a particular institution, and the case study relates to a comparison of two different evaluations, by two different paradigms, and compares their findings.

Gillham (2000a:1) defines a *case study* as an investigation to answer specific research questions which seeks a range of *different evidence* from the case settings. This evidence can be abstracted and collated to obtain the best possible answers to the research question. The case may be an individual, a group such as a family or class, an institution such as a university or factory, or a large scale community such as a town. All these are *single cases* but *multiple cases* such as several groups or institutions can also be investigated. In any case study, *multiple sources of evidence* should be collected, for example, what subjects say or do, and what is observed (Gillham, 2000a:20; Yin, 1989:23). This evidence should then be linked together. Other major characteristics of a case study are that it investigates a contemporary phenomenon within a real life context and can provide qualitative and/or quantitative data (Olivier, 1999:14; Yin, 1989:23). A case study is often used in such a situation to explain causal links in real-life situations when it is difficult, complex or impossible to use other research methods such as experiments (Gillham, 2000a:11; Yin, 1989:25). In such cases, the data obtained would be more comprehensive than that obtained from a survey among a sample of the population.

When a case study is the main method, other sub-methods such as interviews, observations, document analysis, etc. can be used within it. This is done in order to collect as much evidence as possible. This approach is known as triangulation (Gillham, 2000a:13) and is adopted in this study where more than one method is applied in the evaluation of the target system. Olivier (1999:123) points out that a survey can be made of all the members within a case study.

Case study research was originally seen as a weak research methodology but since the 1980s it has been extensively used in academic research, especially in social sciences (Yin, 1989:10). Even though case study research is rare in Information Technology (Olivier, 1999:121), it is well-suited for Information Systems (IS) research (Myers, 1997:242).

1.6.2 Context of the present case study

The researcher is a lecturer at Walter Sisulu University (WSU) situated in East London in the Eastern Cape Province of South Africa. He is the subject co-ordinator of Information Systems 3 in the Department of Computer Studies. A subject co-ordinator is responsible for the preparation of all study materials, such as notes, tests and practical exercises for the subject. Three groups of learners take this subject, making a total of approximately eighty learners annually. The co-ordinator lectures one of these groups. The Information Systems 3 subject entails a one-year programme, in which 'Advanced Databases' is done during the first semester and 'Project Management' in the second.

In 2003 the institution decided to introduce e-learning. In November 2003 and December 2004 one-week workshops were held to train staff in the use of WebCT™, a tool for developing web-based learning applications. The researcher attended both workshops. In December 2004 and January 2005, during the end-of-year recess, the researcher used WebCT^{TM} to develop Info3Net, a website for Information Systems 3. This e-learning application was used with all three groups of learners in 2005 to supplement the traditional face-to-face teaching and learning.

Although the site has been updated and maintained since its introduction, its structure remained unchanged up to the time of its evaluation. Additions such as test dates were made and extra content was added, but the ‘look-and-feel’ and the navigational structure of the site remained constant since its inception. This ensured that the evaluation performed by experts and the one undertaken among learners were of the same site.

1.6.3 Steps in data collection and analysis

It was decided that the following steps would be taken to collect data and analyse it:

1. Establish criteria for usability evaluation of e-learning applications, in particular, web-based learning applications. This will answer one of the research subquestions in Section 1.2.
2. Design a questionnaire to be used for survey evaluation among all the learners using the site in 2005.
3. Perform a pilot study with about five learners in order to test the survey documentation and process.
4. Carry out the full evaluation with all the learners in order to identify problems in the application.
5. Take a sample of about ten learners and interview them to elaborate the problems, and possibly identify more problems.
6. Use four expert evaluators to perform heuristic evaluation on the application in order to determine usability problems in the website. Nielsen (1994:33) recommends that three to five evaluators be used, hence four is considered to be an appropriate number. This step includes severity rating of the problems.

7. Analyse the data collected so as to determine answers to another research subquestion in Section 1.2, in particular how the usability problems identified using heuristic evaluation compare with those identified by users in the survey and interviews.

Where possible, some of these steps should be done in parallel.

1.6.4 Rationale for the methodology used

The following points give reasons why a case study is used as the main research method and expand briefly on ways in which it is implemented:

1. The study is conducted within a real-life context as advocated in Section 1.6.1.
2. The researcher is familiar with the setting in which the case is based. This is recommended for case study research, since it helps to build trust between the researcher and the study participants (Gillham, 2000a:15; Lepisto & Ovaska, 2004:305).
3. Within the case study, various methods were applied as advocated in Section 1.6.1. A questionnaire survey of the population was conducted, as well as an interview survey among a small group. These methods of end-user evaluation were used because other methods of determining end users' usability problems, such as controlled usability testing or experiments, would require more extensive resources and time beyond the scope of this study.
4. A single case is used in this study, because only learners in the stated institution have access to this particular website. However, two main sources of data were used, as well as two main forms of evaluation, providing the ‘different evidence’ required by Gilham (Section 1.6.1) and the means of comparison required by the present researcher.

Though the main research method is a case study, the focus of this study is usability evaluation in the domain of web-based learning. In particular, the study sets out to determine how usability problems identified using heuristic evaluation compare with those identified by end users in a survey and interviews, thus making it a 'comparative case study', as the results of evaluation by two different usability evaluation methods on the same case are analysed and compared.

1.7 Structure of the Study

The study is divided into two main parts:

Part 1: Theory

Chapters 2 to 5 entail literature studies which give background information on e-learning, with emphasis on web-based e-learning applications. Usability is also addressed, concentrating on the main usability evaluation methods and the need for usability evaluation of e-learning applications. These literature studies set the scene and provide the frame of reference for the study. The areas of the study, e-learning and usability, are then integrated by the generation of criteria appropriate for evaluation of web-based e-learning applications (also referred to as web-based learning applications).

Part 2: Practical

Chapters 6 and 7 describe the development and usability evaluation of Info3Net, the web-based application used in the study.

Figure 1.1 depicts the different chapters and their interrelationships. The details of these chapters are described in the next paragraphs.

Chapter 1, the introduction, gives a brief overview of the content and structure of the study. This includes the research problem, the value and scope of the study, the research design and methodology used, and report structure.

Chapter 2 discusses various current learning theories such as the constructivist approach to learning. In Chapter 3, background information is given on instructional design (ID) and e-learning in general. Certain e-learning models are presented and discussed in relation to the learning theory in Chapter 2. Web-based learning, as the main e-learning methodology addressed in this study, is described in detail.

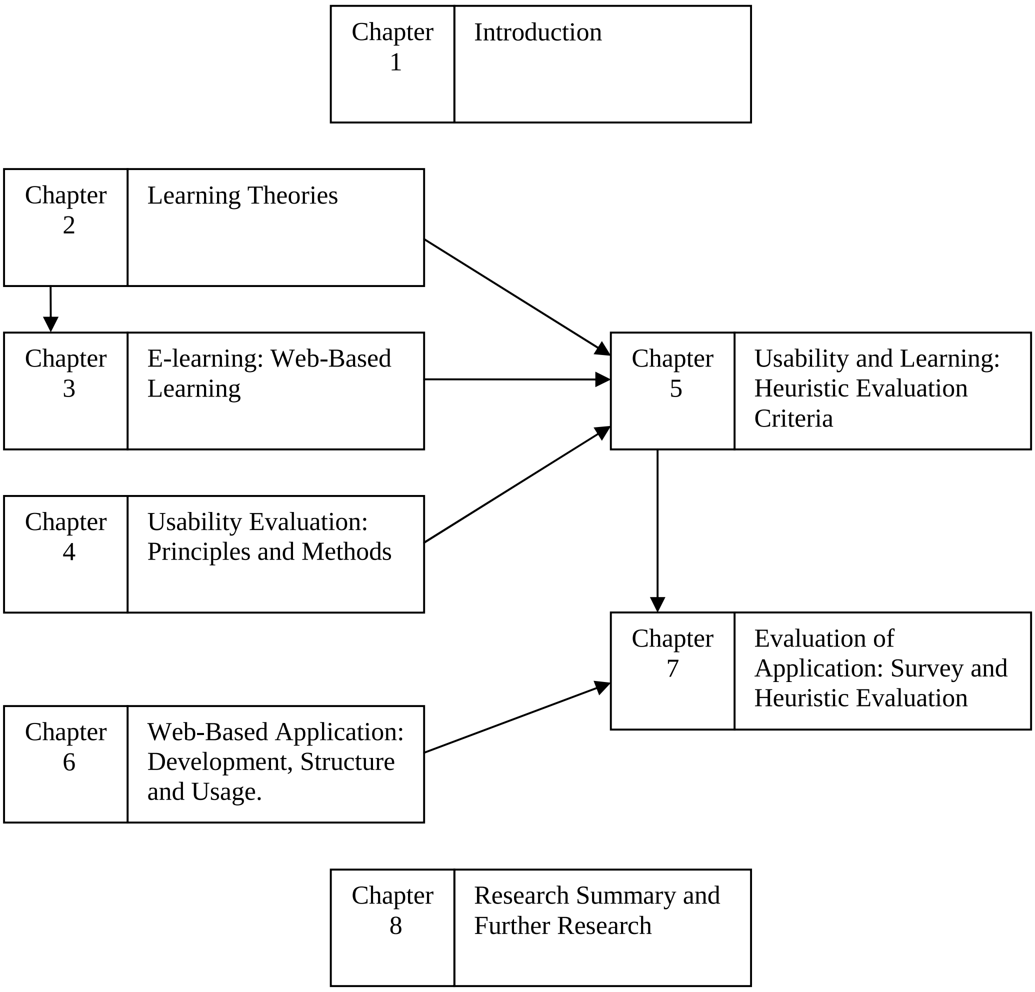

Figure 1.1: Structure of the study

Chapter 4 starts with a discussion of HCI interaction models. It then addresses usability design and principles leading up to detailed analysis and comparison of different usability evaluation methods.

Based on the foundations provided by Chapters 2 to 4, Chapter 5 combines the application domain of web-based learning and the focus area of usability evaluation. Usability criteria for evaluation of web-based e-learning applications are synthesised, focusing on usability issues from the HCI perspective, but also taking cognisance of other factors that facilitate learning, especially web-based learning. The guidelines and heuristics developed here (Chapter 5) are used for the practical evaluations of the site, described in Chapter 7.

Chapter 6 is a description of the development and structure of the Information Systems 3 website used by the learners. The ways in which the learners/students (the words *learner* and *student* will be used interchangeably) and instructor/facilitator use the site are described. This chapter sets the context of the case study.

In Chapter 7, the planning and conducting of a heuristic evaluation by expert evaluators and of a survey evaluation among learners of Info3Net, the Information Systems 3 website, are described. As stated already, the criteria generated in Chapter 5 are used as the basis for the evaluations. The results of both evaluations are recorded, analysed, compared and the main findings are discussed.

Chapter 8 summarises, draws conclusion and makes recommendations.

Chapter 2: Learning Theories

2.1 Introduction

One of the most important aspects of e-learning is the need for careful consideration of the underlying pedagogy, or how learning takes place. In many cases this is neglected (Govindasamy, 2002:287).

This chapter introduces and discusses some of the current learning theories. As Duffy and Jonassen (1991:7) point out, theories of learning and prescriptions for practice must go hand in hand, since prior knowledge and experience influence the way that a designer or educator develops and uses instructional technology. Alessi and Trollip (2001:16) also point out that in the process of developing educational applications and applying them in use, one must assess whether the applications reflect, and are compatible with, an underlying theory of learning. It is therefore important to address the current learning theories on which e-learning, including web-based learning environments, is based. These theories, together with certain instructional design models, are then used as a basis for discussion on e-learning in Chapter 3.

In this chapter behaviourism, cognitivism and constructivism, the three main learning theories (Dewald, 2003:49), are discussed. Other learning models that include elements of these three main ones are briefly described. Though constructivism is a more recent theory of learning, compared to behaviourism and cognitivism, it has emerged as the dominant approach to learning (Ben-Ari,1998:257), and is particularly relevant as an underlying paradigm for e-learning applications. Various principles and practical strategies in line with these three main learning theories are given.

The sources consulted for the discussion in this chapter are largely grounded in the context of educational technology and e-learning.

2.2 Learning Theories

The development of effective learning materials requires an understanding of learning principles. Although no universal agreement exists on how learning takes place, 20th century psychologists and educators have generated several different principles and theories of learning. In the middle of the century, learning theory was dominated by the principles of *behavioural psychology*, maintaining that learning should be viewed as changes in the observable behaviour of the learner as a function of events in the environment. In the 1970s, this principle was expanded by the *cognitive psychology* theory, a perspective which asserts that a complete explanation of human learning also requires consideration of non-observable cognitive constructs, such as memory, mental processing and motivation. In the 1980s, the *constructivist* approach to learning emerged. In contrast with the *objectivist* philosophy, which insists that the world follows real and consistent rules and that learning involves being able to understand and apply those rules to function in the real world, the constructivist philosophy maintains that the individual's interpretation of the world is of prime importance and that each individual constructs his/her own view of reality. Whereas objectivists consider the learner as a passive receptacle to whom knowledge must be imparted by teachers, books, and other instructional media, constructivism views learners as active creators of knowledge, who learn by observing, manipulating, and interpreting the world around them (Alessi & Trollip, 2001:16).

Instructional design (ID) emerged from these *objectivist* traditions. As explained above, objectivism holds that the world is completely and correctly structured in terms of entities, properties and relations. The objectivist approach focuses on identifying the entities, relations and attributes that the learner must know. Behaviourism (Section 2.2.1) and information processing-based cognitive psychology (Section 2.2.2) both fall within the objectivist class (Duffy & Jonassen, 1991:8).

The next three sections discuss behaviourism, cognitivism and constructivism in more detail.

2.2.1 Behaviourism

Behavioural psychology became prominent in the early part of the twentieth century, especially due to Ivan Pavlov's research concerned with classical conditioning. In his experiments, Pavlov discovered that a dog's saliva would flow when a bell was rung, but before food was provided. This saliva flow is regarded as the conditional reflex, and the stimulus, the dish, is called the conditioned stimulus (Black, 1995). Pavlov's discovery was that repeatedly pairing a neutral stimulus with a natural stimulus caused the neutral stimulus to also elicit the response. This led to the behaviourist theory of learning. According to behaviourism, human behaviour is a product of *stimulus-response* interaction. The implication is that people learn various behaviours by pairing them with basic human needs and responses, such as the need for food, sleep and reproduction. Because of this, the proponents of behavioural philosophy maintain that the psychology of learning should be based on the study of observable behaviours and environmental events. They maintain that discussion of non-observable constructs, such as memory, beliefs or the mind are detrimental to the study of learning (Alessi & Trollip, 2001:17). In a similar vein, Black (1995) states that all complex behaviours, including reasoning, habit, and emotional reactions are composed of simple stimulus-response events that can be seen and measured.

Behavioural psychology has implications for teaching and learning. For example, in supporting the behavioural approach to learning, Gagne proposes nine events of instruction that provide external conditioning for learning (Gagne & Glaser, 1987:65):

1. Gaining attention;
2. Informing learner of lesson objectives;
3. Stimulating recall of prior knowledge;
4. Presenting stimuli with distinguishing features;
5. Guiding learners;
6. Eliciting performance;
7. Providing informative feedback;
8. Assessing performance; and
9. Enhancing retention and transfer.

In general, behavioural psychologists suggest the following with regard to learning and teaching (Black, 1995):

- Learners need grades, tangible rewards and other incentives as motivation to learn and accomplish educational requirements;
- Learners should be graded according to their standard of achievement; and
- The curriculum should be structured according to subject content that is organised in a particular sequence.

Alessi and Trollip (2001:18) point out that behavioural psychology and learning theory led to developments such as programmed-instruction textbooks and teaching based on extrinsic rewarding of learners, resulting in a stimulus-response-reinforcement paradigm. In the approach of *programmed-instruction learning*, subject matter is subdivided into small understandable steps, each followed by a question, which, in most cases, the learners should be able to answer correctly. This has the effect of reinforcing the learning process, since by answering the question correctly the learner feels rewarded (Black, 1995).

Behaviourism led to the development and design of the following instructional technologies (Black,1995):

- **Teaching machines**: These use the principle of programmed learning processes to design a self-paced delivery of instruction. There are two methods to do this: linear and branch. In linear design, all learners follow a fixed sequence of frames, whereas in branch design, the response made by a learner determines what follows.
- **Computer-assisted instruction (CAI):** This occurred as a result of the rapid growth of PCs in society. It facilitated the growth of educational software packages. Traditional CAI, popular in the 1980s and 1990s, typically comes in the form of drill-and-practice activities, simulations and tutorials. To program educational applications, the following behavioural principles are followed in sequence:
    - Stating the purpose of the application;
    - Applying the most suitable multimedia, whether in text, visual or audio form;

- Depending on the application, reward or 'punishment' principles are used, where rewards are used to reinforce desirable positive responses, whereas punishment is used for the negative ones – in order to minimise such responses;
- Applying a scoring system to monitor progress; and
- Providing the status of the progress.

- **Virtual reality (VR):** This is useful in areas such as science education because it provides the learner with a three-dimensional (3-D) view of the world. VR has a great potential in the education field since it creates a new learning environment.

Despite its contribution to the processes of learning and teaching, behaviourism has come under criticism. The main criticism is that it ignores important unobservable aspects of learning such as thinking, reflection, memory and motivation. Although the approach is appropriate for teaching intended outcomes, it ignores valuable unintended outcomes, and places too much emphasis on the instructor and instructional material, and too little on the learner. Despite such criticism, the behaviourist approach to learning has exerted a strong influence on teaching and learning. It has triggered many objective experiments and the use of statistical procedures in analysing data related to learning. It has, therefore, proved to be useful to many educators and trainers, and is still used as the basis for the design of many CAI packages (Alessi & Trollip, 2001:19; Black, 1995).

2.2.2 Cognitivism

Cognitive psychology emphasises unobservable mental constructs, such as memory, attitude, motivation, metacognition, reflection, and other internal processes. The first, and one of the dominant schools of cognitive thought is the *human information-processing* approach, which claims that people use their senses to gain information. This information is stored in memory and is either retained or forgotten. It is received and first stored in short-term memory, also referred to as working memory, and must be used or organised in order to become stored in long-term memory, where retention occurs. This belief assumes that the senses and the brain follow complex but systematic laws, and that learning can be facilitated in line with those laws. The second school of thought is the *semantic network theory,* which claims that the brain consists of billions of cells, or nodes, with billions of links or relationships between them characterised by similarity, opposition, cause and effect, or time. According to this theory, remembering, thinking, acting, problem solving, and other cognitive activities occur when information nodes are activated by other nodes. The theory insists that prior knowledge is critical, and that learning is the incorporation of new knowledge into the network of prior knowledge (Alessi & Trollip, 2001:19-20).

The *cognitive domain* and *cognitive education* are some of the other important concepts within cognitive psychology. The concept of cognitive domain addresses the recall or recognition of knowledge, and the development of understanding and intellectual abilities and skills. Cognitive education is the set of instructional methods that assist learners in acquiring knowledge to be recalled or recognised, as well as developing learners' comprehension and intellectual abilities and skills. *Metacognition,* which is the ability of an individual to evaluate his/her own cognitive skills, is an intellectual skill considered to be part of the cognitive domain (Reigeluth & Moore, 1999:52). A high level of cognitive domain within an individual positively influences the learner's ability to learn, and vice versa. Cognitive education, on the other hand, seeks to improve methods of teaching.

Bloom's taxonomy is widely used to categorise types of educational objectives for the cognitive domain. It has become the standard for identifying and classifying educational objectives and activities. Table 2.1 shows Bloom's taxonomy, with the main levels of learning. The levels show the skills a learner should be able to attain at each level. Most current instructional theories seek to move beyond the lower-level objectives to the higher ones, referred to as higher-order thinking skills (Dewald, 2003:50; Reigeluth & Moore, 1999:52). The aim should be to ensure that learners eventually obtain all the levels of skills. In addition to this, educators must evaluate the learner's level of competency, but at the same time the learner should be able to evaluate himself/herself using his/her metacognitive abilities.

1. Knowledge	At this level learners can remember and recall information ranging from concrete to abstract.
2. Comprehension	At the comprehension level, learners are able to understand and make use of something being communicated. Bloom suggests that this level is the major emphasis of schools and tertiary institutions. Comprehension involves translation, interpretation and extrapolation of the information communication.
3. Application	Learners can apply appropriate concepts or abstractions to a problem or situation, even when not prompted to do so.
4. Analysis	Learners can break down material into parts and define the relationships between parts.
5. Synthesis	Learners create a product, combining parts from previous experience and new material to create a new whole.
6. Evaluation	Learners make judgements about the value of materials, ideas and objects.

Table 2.1: Bloom's Taxonomy (Reigeluth & Moore, 1999:52)

Other instructional theorists propose further classifications of learning in the cognitive domain. The following are some of the theorists and the main types of learning they propose (Reigeluth & Moore, 1999:53):

- **Ausubel**
  - *Rote learning*: materials are considered discrete and are learnt without establishing relationships between them.
  - *Meaningful learning*: this takes place if the learning task can be related to what the learner already knows.
- **Gagne**
  - *Verbal information*: the learner may learn to state a fact or describe a set of events using oral speech, or by typing, writing or drawing.
  - *Intellectual skills*: learners interact with the environment by using symbols.
  - *Cognitive strategies*: the individual learns skills which help him/her to manage his/her own learning, remembering and thinking.

- **Anderson**
  - *Declarative knowledge*: this comes in the form of chunks or cognitive units such as propositions or strings of spatial images, i.e. knowledge of 'what'.
  - *Procedural knowledge*: this is the knowledge of how to conduct processes or do things, i.e. knowledge of 'how'.
- **Merrill**
  - *Remembering verbatim*: information is first stored, and then retrieved.
  - *Remembering paraphrased*: idea must be integrated into associative memory and personalised so that it can be re-stated in own words.
  - *Use of generality*: a learner can use a general rule to process specific information.
  - *Find a generality*: a learner can generalise and conceptualise using the knowledge he/she already has.

These taxonomies have similarities, and have been categorised by Reigeluth, as shown in Table 2.2. The table indicates how they relate to Bloom's taxonomy. The final column, *Reigeluth*, shows four general categories under which they can be classified. The second, third and fourth types of learning are particularly relevant to cognitivism. The four categories are discussed below:

- **Memorise information**: This is similar to Bloom's 'knowledge', Ausubel's 'rote learning' and Merrill's 'remember verbatim'. When combined with the 'understand relationships' category, they form a group similar to Gagne's 'verbal information' and Anderson's 'declarative knowledge'. Whereas memorisation is emphasised by behaviourists, cognitivists recommend the use of mnemonics and metacognitive skills to help learners to remember and recall. This approach to learning is commonly used by educators since it is easy to teach and test (Reigeluth & Moore, 1999:54).
- **Understand relationships**: Apart from what has been mentioned above about this category, it is also similar to 'comprehension', 'meaningful learning' and 'remember paraphrased' as indicated in Table 2.2. Understanding is concerned with learning the relationship between elements of knowledge. This is a type of learning that is advocated by cognitivism but not emphasised in behaviourism. Research has been done to determine how this type of learning

occurs, but it remains more difficult to teach and to test than 'memorising information' (Reigeluth & Moore, 1999:54).

- **Apply skills**: This is similar to 'application', 'intellectual skills', 'procedural knowledge' and 'use a generality'. Cognitive learning theory has led to proposals on how to teach and test this type of learning, adding to the approach of behaviourists. However, it remains relatively hard to teach and test (Reigeluth & Moore, 1999:55).
- **Apply generic skills:** This is similar to Bloom's 'analysis', synthesis', and 'evaluation', Gagne's 'cognitive strategy' and Merrill's 'find a generality'. It differs from the previous category (Apply skills) since the skills are not domain-dependent, for they apply to many subject areas. It usually takes longer to acquire generic skills than other skills, and is the most complex to teach and test (Reigeluth & Moore, 1999:55).

Bloom	**Gagne**	**Ausubel**	**Anderson**	**Merrill**	**Reigeluth**
Knowledge	Verbal information	Rote learning	Declarative knowledge	Remember verbatim	Memorise information
Comprehension		Meaningful learning		Remember paraphrased	Understand relationships
Application	Intellectual skills		Procedural knowledge	Use a generality	Apply skills
Analysis Synthesis Evaluation	Cognitive strategy			Find a generality	Apply generic skills

Table 2.2: Instructional Taxonomies (Reigeluth & Moore, 1999:42)

The different forms of learning identified in the various taxonomies are important for instructional designers and e-learning developers in understanding how learning occurs, and how learning content should be taught and tested.

2.2.3 Constructivism

2.2.3.1 Constructivism and learning

The major theme behind constructivist theory is that learning is an *active process* during which learners construct new ideas or concepts based upon their current and past knowledge (Bruner, 1990). Modern theories of learning advocate the constructivist approach to learning, stressing that learning is a distinctive and personal process characterised by individuals developing knowledge and understanding by forming and refining concepts. Learning environments should therefore be provided with multiple knowledge representations and varied cases and context so as to facilitate the exploration of systems, environments and artefacts. Giving learners a sense of ownership over their learning helps them to take responsibility (Reeves & Reeves, 1997:60; Squires, 1999:464; Zhao & Deek, 2006:1589).

In support of these views, Alessi and Trollip (2001:31) suggest that an *objectivist* world view, also referred to as the *instructivist* approach, views instruction or teaching as a process of helping the learner correctly interpret and operate within the real world. Objectivism holds that an absolute or objective reality exists which must be communicated to the learner. Constructivism, in contrast, holds that the only forms of reality are learners' individual interpretations of what they perceive. Constructivists consider knowledge to be contextual in nature, since it must occur within a meaningful context. Moreover, knowledge is created by individuals, and is shared through collaboration with others (Kang & Byun, 2001:48).

There are different schools within constructivism. For example, according to the *social constructivist* school, learning is inherently social and what is learnt is a function of social norms and interpretations, therefore, knowledge is not constructed by the individual, but rather by social groups. *Moderate* approaches to constructivism maintain that there is indeed a real world but that each individual has his/her own personal and changing interpretation of a given concept. The more *radical* approaches hold that one can never really know the exact nature of the real world, so that personalised interpretations are of vital importance.

Since the common constructivist ground is that learning is the process of learners actively constructing knowledge, traditional instructional methods, such as demonstrating, encouraging memorisation and imitation are deemed incompatible with this point of view. Some constructivists propose that people learn most things better by means of participative activities such as writing, computer games, or multimedia composition than through traditional methods of directly teaching content (Alessi & Trollip, 2001:31).

Proponents of constructivism point out that education has been biased towards objectivism, treating learners as passive vessels into which knowledge is poured. However, educators should take the role of coaches, facilitators, or even partners, with learners. It follows, as has been stated, that the goal of designers of educational technology should be the creation of environments that facilitate the construction of knowledge. The following principles or suggestions are promoted as ways of accomplishing that goal (Alessi & Trollip, 2001:32):

- Emphasise learning rather than teaching;
- Emphasise the actions and thinking of learners rather than of educators;
- Emphasise active learning;
- Use discovery or guided-discovery approaches;
- Encourage learner construction of information;
- Use cooperative or collaborative learning activities;
- Use purposeful or authentic learning activities that are relevant to the learner;
- Encourage personal autonomy on the part of learners;
- Support learner reflection;
- Support learner ownership of learning and activities; and
- Encourage learners to accept and reflect on the complexity of the real world.

In line with the above principles, purposeful knowledge construction may be facilitated by learning environments that (Jonassen, 1994:35):

- Provide multiple representations of reality;
- Avoid oversimplification of instruction by representing the natural complexity of the real world;

- Focus on knowledge construction;
- Present authentic tasks by use of contextualised rather than abstract instruction;
- Provide real-world case-based learning environments, rather than predetermined instructional sequences;
- Enable context- and content-dependent knowledge construction; and
- Support collaborative construction of knowledge through social negotiation, but not through competition between learners.

In summary, according to the constructivist approach to learning, learners should be given ownership of their learning, encouraged to explore, provided with meaningful real-world learning tasks, and should collaborate with educators and peers in order to discover and make meaning of new knowledge.

2.2.3.2 Challenges of constructivist design

This subsection presents a number of challenges and suggestions in relation to constructivist design, as exemplified by Jonassen, Winn, Willis, and Brooks and Brooks:

Jonassen: principles of constructivist design

Under constructivism, each individual is responsible for his/her knowledge construction. One of the challenges for constructivist designers is how to determine and ensure a common set of outcomes for learners. Some of the principles mentioned in the previous section are relevant, but are not appropriate for instructional designers since they do not provide a replicable methodology. However, constructivists do not support the view that learning outcomes are predictable; instead, they suggest that instruction should facilitate, rather than control the learning process. That is why constructivists emphasise the design of learning environments rather than the instructional sequence. This does not mean that there is no design process for constructivist learning, but its design and development are more difficult than designing objectivist instruction. There is no explicit design model for constructivist learning because knowledge construction processes are context-specific (Jonassen, 1994:35-6). Given these arguments, Jonassen (1994:37) suggests certain constructivist principles in line with Section 2.2.3.1:

- **Construction of knowledge that is based on internal and social negotiations:** Internal negotiations are based on an individual's mental models, which are used to explain, infer, predict and reflect ideas, and social negations refer to the process of sharing reality with others.
- **Provision of a meaningful and authentic context for learning**: Where appropriate, the problems presented should be based on situations that could be encountered in the real world.
- **Collaboration among learners with the educator as a coach/mentor**: Educators should encourage peer-to-peer learning.

Winn: reconceptualisation of instructional design

Some designers are reluctant to abandon their traditional assumptions with regard to learning, especially the procedural approach to ID. However, there is a need for reconceptualisation of certain aspects of ID to make it suitable for constructivist learning. Winn offers the following suggestions (Winn, 1992:178-9):

- **An emphasis on learning rather than performance and instruction:** Traditionally, curriculum developers and instructional designers set goals and objectives for learning. This means that both content and strategy are imposed on the learner from outside. Under constructivism, by contrast, learners select or develop their own learning strategies, and in many instances, their own goals and objectives. Rather than an emphasis on instruction and performance, learners are given the choice of what to learn and how to learn it. The role of the teacher/facilitator or instructional system is to support what the learner decides to do within a defined context or scope.
- **A different role for technology:** According to constructivists, computer technology should be used to promote learning, rather than to promote direct teaching, by providing environments where learners can explore learning artefacts.
- **Doing design differently**: Given the diminished role of instruction and performance, and with delivery systems that do not deliver content, the role of e-learning designers becomes challenging and more difficult. However, some knowledge needs to be provided as an initial

basis for learners. The ability of learners to support the construction of meaning varies from learner to learner. Delivery systems must be flexible enough to provide varying amounts of guidance as the need arises. Selection of strategies, and even of some content, should be shifted to the moment an individual learns and not be determined upfront by the designer, i.e. a point-of-need approach.

Willis: differences between constructivist design models and traditional ID models

Willis (2000:6) identifies the following major differences between constructivist design models and traditional ID models:

- **It is process-based rather than procedure-based**. Whereas traditional ID models prescribe a set of procedures to be followed in designing instruction, the constructivist approach emphasises the process of decision-making that is involved in designing systems and environments for learning.
- **It is question-driven rather than task-driven**. Instead of following a linear sequence of prescribed steps, designers could use a question-based approach to learning.
- **Spiral cycles are used instead of discrete stages**. Discrete stages, such as analysis, design, implementation and evaluation as used in traditional ID should be avoided; instead an iterative approach should be adopted.

Brooks and Brooks: practical strategies

Constructivism is not a prescriptive teaching theory, but a philosophy relating to knowledge and learning (Brooks & Brooks, 2001). This poses a challenge to educators as to how to become constructivist educators. Brooks and Brooks (2001) recommend practical strategies for constructivist educators:

- Encourage and accept learner autonomy and initiative;
- Use raw data and primary sources, along with manipulative, interactive, and physical material;
- Use cognitive terminology such as ‘classify’, ‘analyse’, ‘predict’ and ‘create’, when framing tasks for learners;

- Allow the learners' responses to drive lessons, shift instruction strategies and adapt the content;
- Inquire about learners' understanding of concepts before sharing their own;
- Encourage learners to engage in dialogue with both the educator and other learners;
- Encourage learners' inquiries by asking thoughtful, open-ended questions;
- Encourage learners to question one another;
- Seek elaboration of learners' initial responses;
- Engage learners in experiences that might generate contradictions to their initial conception, and lead to subsequent discussion;
- Allow waiting time after posing questions;
- Provide time for learners to construct relationships and create metaphors; and
- Nurture learners' natural curiosity through frequent use of the learning cycle model, which will be described in Section 2.2.4.1.

Constructivist design should not replace objectivist design, but designers should be able to select, use and adapt attributes from the various different approaches, so as to suit the instructional methods to the nature of the problem at hand (Jonassen, 1994:35-7). Instructional designers using the traditional approach should gradually evolve their approach and implement the suggestions in this section if they are to incorporate constructivist-learning theories in their designs. The present author views constructivist learning principles, and the means of implementing them, as important guidelines that should be incorporated in the design, development and application of educational applications, such as those for web-based e-learning.

2.2.4 Other learning theories and models

Apart from the three primary approaches, there are various integrated theories and models of learning, such as the *learning cycle* and the *Hexa-C Metamodel*, that have been suggested by researchers. These should be viewed not as different approaches, but rather as augmentations to one or more of the three main perspectives.

2.2.4.1 The learning cycle

According to Mayes and Fowler (1999:487), four fundamental points about learning are that:

1. Learning is best viewed as a byproduct of understanding, and understanding must be built by the individual learner in the performance of tasks;
2. The growth of understanding depends on frequent feedback, particularly from educators and peers;
3. Learning should be modelled as a progression through stages; and
4. All learning is situated in a personal, social and organisational context.

Learning should therefore not be thought of as a discrete activity but as a process of continuous growth, in any domain. This process forms a cycle, the *learning cycle*, comprising the following phases (Mayes & Fowler, 1999:489):

- **Conceptualisation:** This is the user's initial contact with concepts developed or proposed by others. It involves an interaction between what the learner already knows and the new knowledge.
- **Construction:** It refers to the process of integration of concepts, through their use in the performance of meaningful tasks. Traditionally these include tasks like laboratory work, writing, and preparing presentations. The construction phase results in products such as essays, notes, and laboratory reports. Author's note: These products can include computer-generated artefacts by learners, such as spreadsheets, documents produced using word processors, and slide show presentations.
- **Application:** This is the testing and tuning of a learner's understanding of concepts by using them in applied contexts, particularly the testing of understanding of abstract concepts. Conceptualisations are tested and further developed during interaction with both educator and fellow learners.

2.2.4.2 Hexa-C Metamodel

The Hexa-C Metamodel (De Villiers, 1999:1447; De Villiers, 2003:596) consists of six inter-related stances or elements that should be considered in the process of developing interactive educational applications or environments for learning. These stances are based on contemporary learning theories and practice. The elements of the model are:

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

There are six of them, hence ‘Hexa’ and each starts with ‘C’, hence ‘C’. The framework is termed a ‘Metamodel’ because it is a synthesis of existing models. Three of the elements: constructivism, cognitive learning theory, and the aspect of components, are primarily theoretical concepts, whereas the aspects of collaborative learning, creativity, and customised learning, tend to be practical characteristics of learning environments. These different elements will be discussed in more detail, in Section 3.3.2, though some have already been introduced, for example, Constructivism, Section 2.2.3. The idea is not that each element should be incorporated into every learning environment, but rather that those which are appropriate should be explicitly designed into an application. According to De Villiers (2003:595), the model can be used both as a design aid and as a tool for evaluation of existing environments and resources – evaluation from the perspective of instructional and learning theory.

2.3 Conclusion

The development of effective learning and e-learning materials requires an understanding of learning principles. There are a number of learning theories, with behaviourism, cognitivism and constructivism being the three major approaches. Current tendencies support the constructivist approach to learning, which stresses that learning is a personal distinctive process characterised by individuals developing knowledge and understanding as they personally form and refine concepts. The goal of instructional designers should be the creation of educational environments that facilitate knowledge construction. In order to do this, learners should be given ownership of their learning, encouraged to explore, and supported in collaboration with educators, facilitators and peers in order to discover and make meaning of new knowledge.

The various learning theories and models examined in Chapter 2 form a conceptual basis for teaching and learning. The next chapter describes how such theories can be practically applied within e-learning environments.

Chapter 3: E-learning: Web-Based Learning

3.1 Introduction

E-learning is a form of teaching and learning that includes instruction delivered via all electronic media including the Internet/intranets/extranets, satellite broadcasts, video/audio tape, interactive TV, and CD-ROM (Govindasamy, 2002:288). E-learning can be viewed as "electronic learning", "electronically mediated learning" (Wang, 2003:75) or digitally delivered learning (Singh, 2003:51). It is a way of learning using modern information and communication technology (Gill, 2003:21; Welle-Strand & Thune, 2003:185). The concept of e-learning, therefore, includes educational software such as computer-aided instruction (CAI) and multimedia CD-ROMs, as well as the use of the Web and Internet in supporting and managing learning. It is used both in formal education at all levels and in vocational training. The value of e-learning, according to Govindasamy (2002:288), in the context of e-training, does not lie in its ability to train just anyone, anytime, anywhere, but in training the right people to gain the right skills or knowledge, at the right time.

Of all the e-learning delivery media, the Web is the most common medium for delivering material for learning and instruction (Alessi & Trollip, 2001:12). In Section 3.2 of this chapter, e-learning in general is discussed in relation to instructional design (ID) and learning theories such as constructivism, which were presented in Chapter 2. Some of the main e-learning models are examined in Section 3.3. Web-based learning (WBL), one of the focus areas of this study and a particularly valuable form of e-learning, is discussed in detail in Sections 3.4 to 3.6.

3.2 Instructional Design and E-learning

Instructional design is closely related to learning principles and theories such as behaviourism, constructivism and the learning cycle, which were discussed in Section 2.2 in Chapter 2. The philosophical perspective and underlying learning theory on which an e-learning environment or educational software application is based, determines the design approach used by the course developer to implement the system.

The next section, Section 3.2.1, is an overview of instructional design and e-learning. This is followed, in Section 3.2.2, by a discussion of the history and components of e-learning, leading up to an examination of some of the more recent e-learning models applied in the design, development and use of educational applications.

3.2.1 Overview of instructional design and e-learning

Instruction can be defined as a way of organising and sequencing information in order to maximise the transfer of information from educator to learner (Dillon & Zhu, 1997:221). *Instructional design* (ID) is the systematic planning and development of instruction (Ruffini, 2000:58). It involves a set of decision-making procedures by means of which the most effective instructional strategies are developed or chosen, given the outcomes learners are to achieve and the conditions under which they are to achieve them (Winn, 1990:53). The design of any instruction usually involves the use of instructional theories, design models and strategies, to help learners develop knowledge and skills (Dijkstra, 2001:282). Any learning session in any form, whether face-to-face, at a distance or delivered electronically, should provide opportunities for the learner to interact, control the information the learner processes, and give and receive feedback about the knowledge being constructed. E-learning is an instructional methodology (Gill, 2003:21) that uses information and communication technology (ICT) to support learning, as stated in Section 3.1.

Since the Web has established itself as the main delivery medium in e-learning (El-Tigi & Branch, 1997:23), it is important that sound principles of ID are followed when developing web-based learning environments (Ruffini, 2000:58). If the Web, as a powerful and innovative technology, is merely used to make instruction aesthetically appealing and more efficient than in traditional contact teaching, then it does not make any difference to learning. Instructors must not place educational material online without sound pedagogical reason (an occurrence which is found in many online teaching packages), but should instead use the Web to enable learners to process information in ways that inform authentic inquiry or activity (Oliver, 2000:14).

The next sections review the background, theories and some models of e-learning.

3.2.2 History of educational computing

Educators and computer scientists have used computers for instructional purposes for the last four decades, during which time computer technology has evolved and its availability has increased immensely. In the 1960s and 1970s, educational computing took place primarily in large universities, using mainframe computers, and was mainly restricted to reading and typing text. The development of the microcomputer in the late 1970s led to a rapid spread of computing in schools, businesses and homes. Interaction with computers became possible via text, graphics, voice and pointing. The release of personal computers (PCs) in the early 1980s resulted in wide expansion of computer use in both business and industry. The development in computer networks, from LANs to WANs, and to the Internet, permitted the sharing of information and resources. In the early 1990s, the creation of part of the Internet known as the World Wide Web (WWW) or the Web, transformed the entire computing landscape. The Internet has transformed from a network used by academia and government for exchange of textual material, into a worldwide multimedia resource. It is used by millions of people worldwide for activities such as learning, shopping, researching, and the exchange of textual, audio and graphic information. These advances have been accomplished by a dramatic decrease in cost (Alessi & Trollip, 2001:3-4).

Educational computing commenced with a few huge projects on mainframes and minicomputers. These systems were sophisticated and had features similar to those available on the Web today. However, their communication cost and other expenses were high. This, and the advent of microcomputers, led to the takeover by desktop computers. An unfortunate consequence was that the many benefits that had been gained in networked computers were lost. Furthermore, several years passed before microcomputer-based authoring software became available for developing instructional programs that were as sophisticated as their mainframe predecessors. Current educational computing faces problems such as a lack of practitioners skilled in developing quality courseware, and disagreements on how computers should be used in education. Despite these drawbacks, the use of computers for training and education is expanding rapidly, largely because of the popularity of the Internet and the WWW (Alessi & Trollip, 2001:4-5).

The field of educational computing is still evolving. Though conclusive research has not been done to determine the gains and effectiveness of using computers, it is widely accepted that computer-based instruction (CBI) can, at least, reduce the time spent in learning. If properly used, computers can improve learning effectiveness and efficiency. Though progress has been made, much remains to be learned regarding the best ways to harness the power of available technology. The proliferation of educational and training applications on the Internet will, hopefully, result in improvements in the quality of materials for instruction and learning (Alessi & Trollip, 2001:5).

After investigating the history of e-learning and some of the debate surrounding it, the next section discusses an instructional model that holds potential for use in any learning environment, including e-learning.

3.2.3 A generic instructional model

As stated in Section 3.1, instructional design should be closely related to appropriate learning principles and models, as discussed in Chapter 2. Due to the debate on the constructivist and instructivist approaches to learning, *instruction/teaching* has been portrayed as an approach whereby knowledge is given to people, while *learning* is the process where people obtain knowledge for themselves. This is a confusing and artificial distinction since the two of them should go hand in hand. Instruction should be taken as the creation and use of environments in which learning is facilitated. Although instruction can be strictly directed or can be mainly open-ended, most of it falls in between (Alessi & Trollip, 2001:7). This belief corresponds to the proposed combination of the objectivist and constructivist approaches (Jonassen, 1994:37) discussed in Section 2.2.3.2, where it is also concluded that attributes from both approaches should be considered during instructional design. The integration of aspects from both perspectives (objectivist and constructivist) in instructional design is termed a *hybrid* approach.

According to Alessi and Trollip (2001:7), the following four activities/phases extracted from Gagne's nine events of instruction, described under behaviourism in Section 2.2.1, constitute a generic instructional model for effective and efficient learning:

- Presentation;
- Guiding the learner;
- Practising; and
- Assessing learning.

The next sections discuss each of these phases in more detail.

3.2.3.1 Presenting information

For something new to be taught, information must first be presented, for example, by use of rules or examples. To teach skills such as how to extract information from a database, the instructor may have to model the skills to be learned so that the learner can imitate them. Giving examples is a good method of initially presenting information, though more than one example may be needed before the learner gains the skill or apply the rules. Reading materials, such as textbooks, and watching videotapes on how an activity is performed are ways of presenting information (Alessi & Trollip, 2001:8).

The idea of presentation of information – although a basic behaviourist principle – is also supported by constructivists, Duffy and Jonassen (1991:197) who suggest that learners should be provided with some explicitly expressed knowledge as a starting point of the learning process.

3.2.3.2 Guiding the learner

Whereas the first phase of presenting information is instructor- or media-centred, this stage is more interactive and involves both the learner and the medium. The role of the educator or medium at this stage is to observe the learner, correct errors and give suggestions or hints. The most common method of guiding learners is asking them questions and providing feedback to their responses. Guidance is important because it is not easy to learn something in a single exposure (Alessi & Trollip, 2001:8).

3.2.3.3 Practice

If material is to be learnt permanently then repeated practice is required. This is a learner-centred activity where the emphasis is on the learner practising while the instructor makes short supportive or corrective statements. Repeated practice will not only result in speed and fluency but also retention (Alessi & Trollip, 2001:9).

3.2.3.4 Assessing learning

This may not always be considered as one of the phases of instruction, but it is, since it is important to evaluate to what extent learning has occurred. This is normally done in the form of a test. Tests should be done not just to grade learners, but as a means of guiding instructional decisions, such as determining the different instructional needs of the varying learners (Alessi & Trollip, 2001:10).

Each of the phases discussed can be facilitated by one or more of the different e-learning multimedia “methodologies” (Alessi & Trollip, 2001:10). The next section discusses these methodologies.

3.2.4 Methodologies for interactive multimedia that facilitate learning

The following methodologies provide the basic background for understanding and developing good interactive multimedia to implement either the instructivist or constructivist approaches to learning (Alessi & Trollip, 2001:10-12):

- **Tutorials**: These are normally used to accomplish the first two phases of instruction (see Section 3.2.3), i.e. for presenting and guiding the learner in the initial interaction with the information.

- **Hypermedia**: These programmes are used for the presentation of information, especially in open-ended or constructivist learning experiences. Since they are less structured than tutorials, they can be followed in a hyper-linked branched fashion rather than a linear one. This allows learners to choose their own different paths, resulting in some degree of individual control of their learning. This is highly recommended in the constructivist approach to learning as set out in Section 2.2.3.1.
- **Drills**: Drills are designed to assist learners in practising for fluency and retention. Drills and games methodologies are often combined in order to motive learners.
- **Simulations**: Simulations can be used to cover any of the four phases of instruction. They can also be used for objectivist or constructivist learning. Simulations may also be combined with games in order to foster discovery learning.
- **Games**: Games are normally used for practice. However, they are sometimes combined with other methodologies to support other phases; for example, they can be combined with simulations to create discovery environments.
- **Tools and open-ended learning environments**: These are computer applications that learners can control themselves, usually in combination with other media, in order to achieve some educational goals. They are, by their nature, more open-ended and flexible, and therefore support constructivist learning, though they can be used in objectivist learning. They can be used during any phase of instruction.
- **Tests**: These are normally used in the last phase of instruction to assess learners, although they can also be used during interactive practice, in the form of practice tests and quizzes.
- **Web-based learning environments**: The Web is essentially a delivery medium that can be used in combination with any of the other methodologies for any of the four phases of instruction. It is currently mostly used in conjunction with the hypermedia methodology.

It is important to note that in a given lesson, a combination of methodologies is likely to be used.

Because of its importance as a method for delivering material for learning and instruction, and its potential to be used in combination with any of the other methodologies, in any of the phases of instruction, Section 3.4 will be devoted to web-based learning, which is also one of the focus areas of this study. However, in order to address the different instructional methodologies discussed in this section and the various phases of instruction such as those in the instructional model of Section 3.2.3, it is important first to mention various classifications of e-learning. This is done in the next section.

3.2.5 Classification of e-learning courseware

There are various ways by which e-learning courseware can be classified.

3.2.5.1 Classification according to source or origin of courseware

Courseware can be classified based on the way it originated and the way it maps to the type of learning (Mayes & Fowler, 1999:490):

- ***Primary Courseware****:* This is courseware mainly intended to present subject matter. It would normally be authored by subject matter experts, but is usually designed and programmed by courseware specialists. Most of the current courseware falls into this category. Some textbook publishers supply the content of the textbook as slides for presentations to be used by educators in class. This is a passive form of primary courseware. An active form could be an interactive tutorial.
- **Secondary courseware:** It describes the environment and the set of tools by which learners perform learning tasks themselves. This includes support tools like word processors and spreadsheets, which learners use to perform their tasks. For example, a word processor could be used to write an essay about the learned content.
- **Tertiary courseware:** This is material that was produced by previous learners and tutors, peer discussions or output from assessment, and is shared among the learners. Tertiary courseware is a relatively new concept in educational software. Examples are a recorded discussion between peers that is structured and stored in a database for later use, or a project done by a previous learner.

3.2.5.2 Bounded and unbounded material

Teaching and learning can be done using interactive multimedia products such as CD-ROMs or Web pages. In this situation, teaching and learning should not be equated to teacher and learner. Both the teacher and learner should be involved in the activities of teaching and learning, especially in cooperative and collaborative situations. It is important to note the difference between *bounded* materials such as CD-ROMs and tutorial, and *unbounded* ones like Web resources. The ability to access unbounded or dynamic information is what distinguishes web-based instruction (WBI) from instruction using bounded interactive multimedia materials (Hedberg, Brown & Arrighi, 1997:49).

What is also important about WBI is not its rich mix of media features such as text, graphics, sound, animation, and video, nor its linkage to information resources around the world, but the pedagogical dimensions that it can deliver (Reeves & Reeves, 1997:59).

3.2.5.3 Well-structured and ill-structured domains

Well-structured or closed domains contain concepts where rules are prescribed and problems solved by objective principles. Such domains are usually procedural or algorithmic and occur in syntactic, mathematical, and computational subject matter. *Ill-structured* or open domains, on the other hand, contain problems with multiple solutions and alternative approaches. They are usually found in areas such as social sciences, business sciences and design disciplines (De Villiers, 2003:598).

3.2.5.4 Full and empty technologies

Full technologies are used for teaching content. They are referred to as full, because they contain information that should be transferred to the learner. Examples of full technologies are CAI and intelligent tutoring agents. Primary courseware falls into this category. *Empty technologies* are shells and environments used to promote learning. They can accept any content designed to allow learners to explore and construct meaning for themselves. They act as tools but not as instructions for learners. Secondary courseware falls into this category (Winn, 1992:179).

3.3 E-learning Support Models

There are certain learning models that have been proposed for supporting and/or evaluating e-learning environments, including web-based learning. This section describes two of them. Most of their components relate to pedagogy and learning theories, which will not be discussed in detail here, since they have already been described in Chapter 2.

3.3.1 The Dimensions Model for effective interactive learning

Reeves and Reeves (1997:59-64) developed a model of ten dimensions for interactive learning, suggesting ten continuums, or horizontal axes, along which a learning artefact can be positioned. The dimensions are based on research and theory in instructional technology, cognitive science, and adult education, and are listed below:

1. Pedagogical philosophy;
2. Learning theory;
3. Goal orientation;
4. Task orientation;
5. Source motivation;
6. Educator's role;
7. Metacognitive support;
8. Collaborative learning strategies;
9. Cultural sensitivities; and
10. Structural flexibility.

The continuums for these ten dimensions are shown in Figure 3.1, and each is briefly discussed in the following subsections.

3.3.1.1 Pedagogical philosophy

Dimensions of pedagogical philosophy range from a pure *instructivist* (objectivist) structure to radical *constructivism* (see Section 2.2). Instructivists stress the importance of objectives, ranging from lower- to higher-order learning, and use direct instruction to address each objective in sequence. Many educational applications, including tutorials, use this approach, which is instructor-centred, placing little emphasis on learners, who are viewed as passive recipients of instruction. Constructivists, by contrast, emphasise learners' intentions, experience, and cognitive strategies, regarding them as individuals with pre-existing knowledge, aptitudes, motivation, etc. Direct instruction is replaced with tasks or problems that are personally relevant.

Instructivist	← Philosophy →	Constructivist
Behavioral	← Learning theory →	Cognitive
Focused	← Goal orientation →	General
Academic	← Task orientation →	Authentic
Extrinsic	← Motivation →	Intrinsic
Didactic	← Educator role →	Facilitative
Unsupported	← Metacognitive support →	Integrated
Unsupported	← Collaboration →	Integral
Insensitive	← Cultural sensitivity →	Respectful
Fixed	← Flexibility →	Open

Figure 3.1: The ten continuums of Reeves' model for effective interactive learning (adapted from Reeves & Reeves, 1997:60-64)

3.3.1.2 Learning theory

Educational applications should be based on sound learning theories such as those introduced in Section 2.2. These range from *behavioural* to *cognitive*. According to behaviourists, instruction should involve shaping desirable behaviour through arrangement of stimuli, responses, feedback, and reinforcement. Cognitive psychologists, on the other hand, emphasize internal mental states and believe that a variety of learning strategies including memorisation, direct instruction, deduction, and induction, are required in any learning environment.

3.3.1.3 Goal orientation

The goals of education and training can range from *focused* to *general*. Learning involves the investigation of knowledge and negotiation of meaning to a level at which it is clearly understood. Knowledge might be presented by focused, direct methods, such as tutorials. Other knowledge requires considerable creativity, or is at a high level of abstraction, so that WBL would be more appropriate, since it allows for exploration, which may include several goals.

3.3.1.4 Task orientation

Designs for learners' tasks range from *academic* to *authentic*. Traditional academic tasks can involve routine activities such as providing the missing words in a sentence. By contrast, authentic design considers context of use and sets realistic scenarios. The ways and contexts-of-use in which knowledge, skills, and attitudes are initially learned, impact on the degree to which learning is transferable to other similar contexts.

3.3.1.5 Source motivation

Motivation, varying from *extrinsic* (external to the learning environment) to *intrinsic* (integrated within the learning environment), is a vital factor in any theory or model of learning. All forms of educational technology should be able to motivate learners. WBI is likely to intrinsically motivate learners because of the integration of media, graphics, text and animation. However, learners tend to tire of these elements, so there is a need to use them with caution.

3.3.1.6 Educator's role

Educational applications support different roles for educators – a traditional *didactic role* (telling) or as *facilitator* (guiding) at the other extreme. Even within e-learning, research often remains focused on using computers to present information so that learners can recall it. Many applications support the didactic role with syllabi, class notes and other materials on the Web for easy access. By contrast, learners should be responsible for recognising and judging patterns of information, constructing alternative perspectives, and representing new knowledge in meaningful ways, using the computer to perform routine tasks such as calculations, and storage and retrieval of information. Applications should be designed with interactive assignments and problems to solve, as well as course content. In such cases, the educator can play the role of a facilitator, coach, mentor or guide.

3.3.1.7 Metacognitive support

Metacognitive skills are skills used in learning to learn. Metacognition refers to a learner's awareness of objectives, ability to plan and evaluate learning strategies, and capacity to monitor progress and adjust learning behaviours as needed. Metacognitive support in educational applications ranges from *unsupported* to *integrated*, where the latter encourages learners to think about their strategies as they perform learning tasks and the former does not.

3.3.1.8 Collaborative learning strategies

Collaborative learning strategies can be completely *unsupported* or an *integral* feature of a learning environment. When supported, it entails instructional methods in which learners work together in pairs or small groups to accomplish shared goals. Given an appropriate instructional design, learners working together using an educational application tool might accomplish more than an isolated learner on his/her own. Interaction enables learners to learn from each other.

3.3.1.9 Cultural sensitivities

Cultural sensitivity within an educational application ranges from *insensitive* to *respectful*. Although it is not easy to design applications that are sensitive to all cultures, efforts should be made to accommodate the diverse cultural and ethnical backgrounds of the learners. Individual preferences within the same culture should also be accommodated.

3.3.1.10 Structural flexibility

Interactive learning environments can be *fixed* or *open* with respect to time and/or place. Fixed systems are those restricted to specific venues, such as laboratories or classrooms, at specific times. Open systems such as Web and CD-ROM based material, can be used by learners independent of time and place. The fixed mode limits pedagogical innovation, and simply supplements traditional instructional approaches to teaching and learning. However, the rapid growth of the Internet and the increase of high bandwidth means that interactive learning can be designed for delivery anytime, anywhere, to anyone with a personal computer and high-speed Internet access.

The model discussed in this section and its ten dimensions can be used to inform the design, development and use of e-learning applications. Another model, with different elements, yet with similar objectives is discussed in the next section.

3.3.2 The Hexa-C Metamodel

The Hexa-C Metamodel (HCMm), which was briefly introduced in Section 2.2.4.2, takes into account some current instructional and learning theories and interactive multimedia technologies and practices, to develop an integrated framework for designing and evaluating e-learning (De Villiers, 1999:1447; De Villiers, 2003:595). The model emphasises that technology should be seen as a tool and a medium for learning. Technological advances should not drive e-learning or dictate its form. Rather, the role of technology in learning and instruction should be subservient to learning theories and objectives, as technology supports learning in an appropriate, contextual way.

The model, shown in Figure 3.2, comprises six inter-related elements. Since learning content and instruction differ from one situation to another, these six elements are embedded within *context*. The hub of the framework is *technology*, which is the medium that transfers the message and not the message itself.

De Villiers (2003:604) states that the HCMm is neither an ultimate theoretical solution nor a conventional ID model. It is not the intention that each element should be incorporated into every e-learning application. It serves a role, from the perspective of learning theory, to emphasise features that can enhance design and practice in learning applications. The e-learning designer should consider the six elements and use those that are relevant to the task in hand.

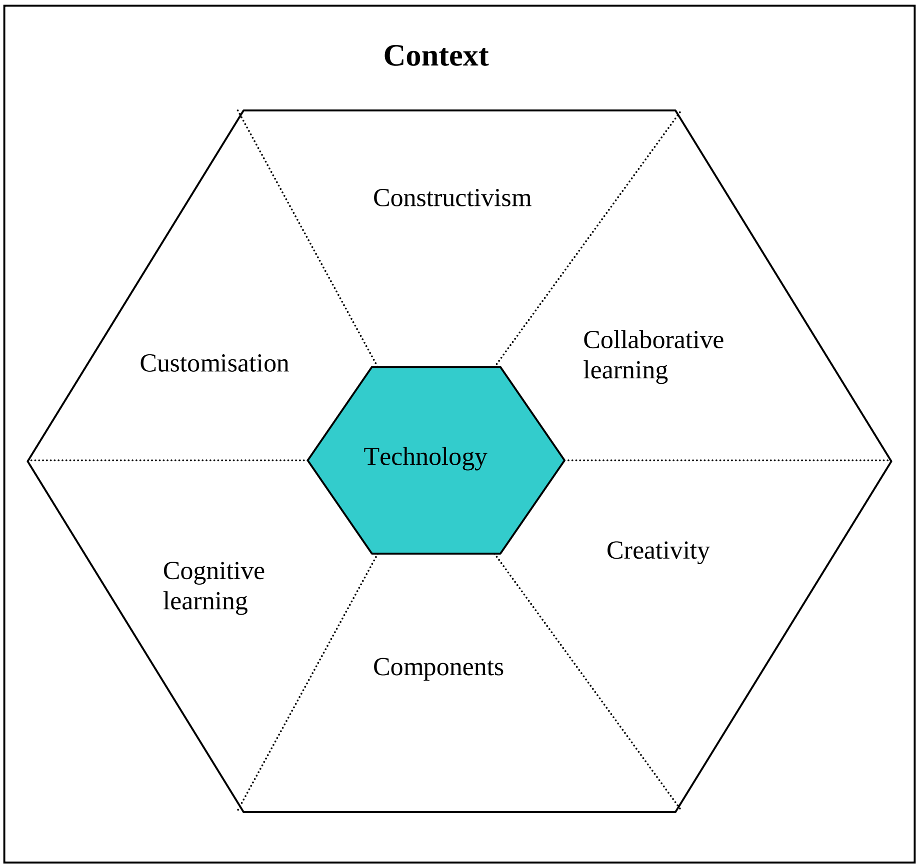

Figure 3.2: The Framework of the Hexa-C Metamodel (De Villiers, 2003:596)

The next subsections elaborate the six Cs and mention possible applications in e-learning (De Villiers, 1999:1447-1449; De Villiers, 2003:596-598).

3.3.2.1 Cognitive learning theory

Cognitive learning theory (see Section 2.2.2) maintains that learning should support cognition, formation of knowledge structures, and retention. Learning is seen as the reorganisation of internal knowledge structures, as learners construct meaning by integrating new knowledge with existing knowledge. One approach within e-learning systems, could be incremental introduction of new learning by alternating learning content sections with question segments and interactive activities.

3.3.2.2 Constructivism

Constructivist learning is based on learners actively constructing their own knowledge (see Section 2.2.3) and can be implemented by educational environments that support problem-based learning, open-ended learning, flexibility, and authentic tasks. Constructivism involves learner-centric environments and activities in which learners use computers as tools to search for material, to manipulate information and to generate their own products. It emphasises collaborative activities using a number of resources.

3.3.2.3 Components

Components relate to the basic knowledge, skills and methods of a domain, which could be unitary or composite components, as well as decontextualised skills. Component display theory (CDT) (Merrill, 1983:283), is an approach that uses components, and is based on relationships between the kind of content taught: fact, concept, procedure or principle, and the level of performance required: to remember, use or find. Computers should be used in ways that capitalise on their unique capabilities, such as interaction and individualisation, all of which are features of CDT.

3.3.2.4 Creativity

Instruction and learning can frequently be dull, prescriptive and formal. Creativity aims to motivate learners intrinsically in order to engage them and strengthen the affective-cognitive bond. The design of educational applications should be characterised by innovative features and learner engagement, which in turn fosters creativity among learners.

3.3.2.5 Customisation

Customisation of learning aims for learner-centric instruction that adapts to individual profiles, supports personal processes and products, and, where appropriate, allows learners to take the initiative regarding the methods, time, place, content, and sequence of learning. Classical CAI includes program control mechanisms that navigate learners through material according to their performance in pre-tests. The current approach, by contrast, especially in WBL, provides more learner control.

3.3.2.6 Collaborative learning

Collaborative learning involves joint work, social negotiation, a team approach, and accountability and peer evaluation. It can be effectively supported by educational technology. For example, co-operative problem solving, two-at-a-computer, has shown itself to be a means of learning and confidence building. Collaborative learning is optimal in contact situations, but can also be applied in distance learning, for example, by using e-mail, bulletin boards, and discussion forums, that provide an infrastructure for teamwork, joint projects, and collaborative problem solving.

3.3.3 Application of the models

The previous two subsections describe models that can be applied in the design and evaluation of e-learning artefacts such as educational applications and web-based environments. Neither of the two models, namely De Villiers' Hexa-C nor Reeves' Dimensions, is a prescriptive or procedural model. Rather, both present the instructional designer with learning-oriented elements and factors to be considered in the development of interactive courses and environments. The 'C' elements selected for implementation in an educational application are context- and content-dependent, as is the positioning of the application on axes of each of Reeves' ten dimensions. Other aspects impacting on the nature of an application are the way in which it is classified according to the various classification systems set out in Section 3.2.5.

With a background of educational software and e-learning in general, as discussed in this section (Section 3.3), the next section focuses on web-based learning.

3.4 Design of Web-Based Learning

3.4.1 Why web-based learning is important

The Web is one the most important and prevalent current technologies (Crossman, 1997:19). Its use as a means and method of delivering material for learning is likely to have a greater influence on learning than all the developments in instructional technology of the past 30 years (Alessi & Trollip, 2001:372).

According to Crossman (1997:19), the World Wide Web is an instructional technology that permits the display of information in any medium, on any subject, in any order, at any time, i.e. asynchronous learning, independent of place, as stated in Section 1.1. This is not possible with traditional contact teaching, where learners and educators go to a particular place, at a particular time, for a particular class on a particular topic. This means that the Internet, in general, and the Web, in particular, have changed the way in which people relate to time and space (Crossman, 1997:21), since the Web is not only used to enhance teaching and learning in the traditional face-to-face environment, but also supports distance learning and teaching by enabling learners to communicate both synchronously and asynchronously (Vrasidas & McIsaac, 2000:105). This type of communication allows for self-paced learning and reflection, which are advocated by the constructivist approach. Such means of teaching and learning have captured the interests of educators world wide. Educators, from pre-school to graduate school, are rethinking the very nature of teaching, learning and educating, due to the existence of web-based learning environments (Owston, 1998).

Synchronous communication occurs where users carry on ‘live’ or immediate conversation via text, audio, or video. It assumes that the users are logged onto the computer network system simultaneously. Chat rooms and whiteboards use this form of communication. Asynchronous communication, on the other hand, occurs where a user posts a message for another user or group of users to respond at his/her or their own convenience. The basic principle of asynchronous communication is that the receiver of the message need not be logged onto the system at the time the message is sent. Examples are electronic mails and online discussion forums, which are common features of online learning environments (Firdyiwek, 1999:29).

With the Web, traditional lectures and teacher presentations can be converted into multimedia learning experiences for learners (Owston, 1998) since it supports the use of colours, handles graphics easily, displays full motion video, and supports very high quality audio, all of which are accessible through commonly-available hardware and software (Crossman, 1997:20; Winn, 1999:271). Jolliffe, Ritter and Stevens (2001:198) list the following resources, which include traditional instructional resources, as part of web-based learning:

- Text;
- Graphics and photographs;
- Presentation programs;
- Audio and video;
- Animations;
- Links to other websites or computer-based resources;
- E-mail;
- Discussion forums; and
- Tutorials.

These resources can be used to enhance WBL as a medium for learning and teaching.

In addition to these resources, the importance of e-learning, especially WBL, stems from the fact that it supports several pedagogical approaches such as (Shneiderman, Borkwowski, Alavi & Norman, 1998:23):

- **Distance education, or telelearning**: Learners need not be in the classroom in order to study, and can participate synchronously or asynchronously with fellow learners or the instructor;
- **Active learning and inquiry-based education**: Learners can solve issues interactively with varying levels of human and computer guidance;
- **Collaborative and cooperative learning**: Collaboration in the form of teamwork results in knowledge acquisition by team members; and
- **Individual and self-paced instruction**: Learners can learn on their own at their own pace with the assistance of e-learning applications.

In summary, the widespread use of the Internet, its use for both synchronous and asynchronous communication, and its support for varying learning theories and pedagogical approaches has made web-based learning an attractive and important mechanism for learning and teaching. Designers of WBL environments should guard against using the Web merely for delivery of content. They should capitalise on the features of interactivity and individualisation to support active learning. The next section gives an overview of some of the features of the Web that make it suitable as a means of learning.

3.4.2 The Web as a means of learning and teaching

The emergence of the Web as an instructional medium can be attributed to its intrinsic nature. It is important to understand the following characteristics of the Web in order to appreciate its use for educational applications (Alessi & Trollip, 2001:373):

- **The Web as a network standard**: The Web is part of the Internet, which evolved in the 1960s. As discussed in Section 3.2.2, the development in computer networks from LANs to WANs, and now to the Internet, permitted the sharing of information and resources. The creation of the Web has enabled users to easily connect and share resources using Web browsers, 24 hours a day from any location (Alessi & Trollip, 2001:374).

- **The Web as a platform**: The Web is a set of standards and software that makes the use of the Internet easy, using Web browsers. Because browsers can run on most software and hardware, the Web is considered to be platform-independent, making it attractive to software users and developers, including those of educational applications (Alessi & Trollip, 2001:374).
- **The Web as a delivery medium**: The Web is primarily used to deliver information from one computer to another. If material is available on the Internet, then millions of people globally can access it. Moreover such material can be modified easily so that all users get the most current version (Alessi & Trollip, 2001:374). Materials delivered via the Web can include the traditional forms of CAI, such as text, hypermedia, interactive tutorials, drills, simulations, games and open-ended environments (Alessi & Trollip, 2001:379).
- **The Web as a communication medium**: The Web has become one of the main communication channels between people. As discussed in Section 3.4.1, communication may be synchronous, where the parties communicate both ways at the same time, or asynchronous where there is a time lag between communicators. Asynchronous communication channels include e-mails, listservs and bulletin boards, whereas synchronous forms include chat rooms, audio teleconferencing and video conferencing. In both types of communication, text, picture, sound and movies can be exchanged (Alessi & Trollip, 2001:375).
- **The Web as a methodology for learning**: Though the Web may not be considered a direct methodology for learning in the same sense as, for example, tutorials, it can be considered as an effective mechanism for education and training, hence the emergency of many forms of study, research and application, termed respectively web-based learning, web-based training, and web-based instruction. The Web is not only used for delivery of instruction but also for creating an environment for learning (Alessi & Trollip, 2001:379).

In order to effectively and efficiently use the Web for learning, guidelines are required, some of which are provided in the next section.

3.4.3 Guidelines for web-based learning

Since instruction is a purposeful interaction to increase the learner's knowledge or skills in specific, pre-determined ways, it means that a website merely with links to other digital resources does not constitute instruction (Ritchie & Hoffman, 1997:135). In order to develop websites that support effective learning, theories and models of learning (as discussed in Chapter 2) including those specific to e-learning (discussed in this chapter) should be considered. These and the way the Web is used for learning, contribute to guidelines for web-based learning environments.

Guidelines identified by the current researcher are listed in Table 3.1, followed by the subsections where they are elaborated.

Aspect	Section where it is elaborated
1. Collaboration	***Section 3.4.3.1***
2. Educator and learner goals	***Section 3.4.3.2***
3. Motivation	***Section 3.4.3.3***
4. Communication	***Section 3.4.3.4***
5. Active learning	***Section 3.4.3.5***
6. Guidance and feedback	***Section 3.4.3.6***
7. Assessment	***Section 3.4.3.7***
8. Learner control	***Section 3.4.3.8***
9. Problem solving	***Section 3.4.3.9***
10. Customisation	***Section 3.4.3.10***
11. Metcognition	***Section 3.4.3.11***
12. Authentic learning	***Section 3.4.3.12***

Table 3.1: Aspects to consider in Web-based learning environments

3.4.3.1 Collaboration

Whether used for on-site or for distance learning, the Web is a good medium for collaboration between learners on activities such as joint course projects (Alessi & Trollip, 2001:380).

Collaborative learning involves inter- and intra-group interactions, where the learner actively participates in the learning process, while solving a problem as a group (Collis, 1999:213). It is not enough merely to divide learners into groups; the learners should recognise the value of trying to learn in this way and consequently must participate actively in group activities. One of the ways of ensuring this is by educators structuring group activities so that there is individual and group assessment (Vat, 2001:328). Collaboration also includes cooperation among educators and learners where both should participate actively in making sure that learning is facilitated (Khan, 1997:17)

Traditionally, learners would enter a physical classroom, take a seat and take notes, but for the *net-generation* – born since 1997 – there is a new paradigm. The net-generation has grown up in a new world, interacting with technologies such as the Internet and e-mail from an early age. For this target group, it is important that interactive activities such as teamwork, group projects, group debates and discussions should be included in learning activities (Frantz & King, 2000:33). These activities increase the feeling of social presence among the members of the group, enhance the existence of the online learning community, increase learner-learner interaction and take advantage of the information and communication technology that can support collaborative work (Vrasidas & McIsaac, 2000:110).

One of the ways to promote collaboration is to provide ‘after learning’ support. Unlike traditional classroom instruction, learners can sometimes use the Web to access learning materials that they previously encountered in their courses. This could be very useful for learners when they enter the job market, for they would still be able to access what they learned at an institution. Similarly, new learners could learn from the former students who are now in the work environment, if collaboration between such groups is facilitated (Alessi & Trollip, 2001:381).

3.4.3.2 Teacher and learner goals

The way information is organised on the Web is determined by the goals of the learner and the knowledge domain intended by the instructor. The website should identify the educational goals and purposes for each document to be delivered on the site (Ardito, Costabile, De Marsico, Lanzilotti, Levialdi, Plantamura, Roselli, Rossano & Tersigni, 2004:188; El-Tigi & Branch, 1997:23). Clear goals should be formulated early in the learning encounter, and after certain intervals, learners should know their progress. Goalsetting helps to motivate learners (Alessi & Trollip, 1991:32; Wein, Piccirilli, Coffey & Flemming, 2000). Intended outcomes should be listed to help learners focus their attention on major aspects (Ritchie & Hoffman, 1997:136).

3.4.3.3 Motivation

Just as any website is intended to attract and retain users, learners should likewise be attracted to sites for learning. They should be engaged by the content and interaction, and their attention should be retained. Graphics, colour, animation and sound, if used properly, can act as external stimuli to motivate learners. The question arises: "How can web-based instruction be created so as to motivate the learner?" (Ritchie & Hoffman, 1997:135). Attention, which results in motivation, can be stimulated through inquiry arousal, in which learners encounter a solved problem. Another motivational strategy is the demonstration of relevance of what is learned, for example, by linking it to a particular real-world task or vocation (Ritchie & Hoffman, 1997:135).

Alessi and Trollip (2001:204-207) suggest the following means of motivation for learners using web-based applications:

- *Reinforcement*: A successful end to an activity should be followed by an enjoyable task, for example, a game after a lengthy tutorial.
- *Challenge*: Appropriate levels of challenge should be provided and maintained to cater for different learners, so that none becomes bored.
- *Competition*: The learner should be able to compete with other learners or with computer-based programs, for example, by stimulating activities and quizzes. The learner could also be encouraged to compete with him/her self by giving opinions in response to challenging questions.
- *Confidence*: There should be reasonable opportunity for the learner to be successful in his/her activities. This confidence should be maintained by providing appropriate objectives and instructions, and by giving encouragement.

- *Control*: Learners' sensory and cognitive curiosity should be aroused by providing opportunities for exploration. Sensory curiosity refers to physical stimuli such as sound and vision, whereas cognitive curiosity refers to mental challenges such as giving explanations.
- *Fantasy*: Learners should be encouraged to envision themselves in a context or event where they can apply the information they are learning.
- *Satisfaction*: Satisfaction should be maintained by providing supportive feedback and encouragement. For example, on choosing an incorrect answer, the learner should be informed courteously why it was wrong and given an opportunity to try again. Eventually the correct answer should be provided with an explanation and possibly a reference to material from which the answer originates.
- *Session length*: To avoid boredom, activities should be subdivided or chunked so that they do not take too long.
- *Variety*: Display and response modes should be varied, for example, by use of text, graphics, colour and sound in the presentation of information, and by use of the mouse, keyboard or touch panels in the manipulation of such information.

3.4.3.4 Communication

Both synchronous and asynchronous communication – described in Section 3.4.2 – have a role to play in contact teaching as well as distance learning and should both be available in web-based learning environments (Alessi & Trollip, 2001:379; Costabile et al, 2005:6). Unlike synchronous communication where the educator has to work as a facilitator and sets the pace of interaction, asynchronous communication enables learners to work at their own pace and control the communication (Vat, 2001:330).

Communication is important in the integration and management of learning since the Web can be used as a central place for a course, where both the learner and the educator post information, do or receive assignments and tests, and communicate with one another. Applications such as WebCT™ enable instructors to build sites easily with course syllabi, reference materials, assignments and tests, and general information such as hours of availability and grading policy

(Alessi & Trollip, 2001:380). The communication channels can be in the form of e-mail, discussions, chat rooms, and listservs (Wein et al, 2000).

3.4.3.5 Active learning

Whereas learners must actively process and make sense of information presented to them in order to learn, active learning rarely occurs through simple interaction with the Web. Learners tend merely to browse superficially, jumping from one page to another. One way of ensuring that active learning occurs, is to require learners to compare, analyse or classify the information, or make deductions from it (Ritchie & Hoffman, 1997:135).

In order to promote active learning, learners should be encouraged to use the Web for research, since it is an extensive source of information. However, some problems exist. First, because of the large volume of information, it is difficult to get relevant information for the required topic. The other problem is concerned with the authenticity of the material. Because it easy for any individual to upload information onto the Web, learners must make sure that the material used is from a reliable source (Alessi & Trollip, 2001:380).

3.4.3.6 Guidance and feedback

Learners should be provided with guidance, for example, by providing links to definitions and examples. In self-learning, diagnostic feedback is important to help learners in self-evaluation and to obtain answers to what they do not understand. Multiple choice questions, where learners select the correct answer from alternatives, need explanations or cross reference to the relevant section, in cases where the answer is incorrect (Ritchie & Hoffman, 1997:136). Feedback in terms of grading of learners' activities by the educator should also be done (Wein et al, 2000).

3.4.3.7 Assessment

In order for learners to integrate the desired knowledge, some form of assessment is required. This can be done online or offline. Online testing can be automated for objective tests or be saved in a file for the instructor to mark later. Assessment can also be done by requiring the learner to develop a product or an artefact, for example, a software product (Ritchie & Hoffman, 1997:137). With tests being the primary method of assessing learning, web-based testing has the advantages of automatic scoring, data storing and analysis, time saving and convenience for both learners and instructors. Where appropriate, learners can do tests when they are ready and the system can be used to grade and allocate marks (Alessi & Trollip, 2001:381).

3.4.3.8 Learner control

Democratic learning environments should be available by giving learners some control of what is learned, how it is learned and the order in which it is learned (Khan, 1997:14).

3.4.3.9 Problem solving

Learners improve their problem-solving abilities when they are faced with real-world problems. Since the Web supports exploration, learners can participate in real-world problem solving (Jun et al, 2002:46). Problem-based learning encourages active construction of knowledge through personal inquiry as well as social negotiation and work with peers (Oliver, 2000:6).

3.4.3.10 Customisation

There should be customisation of learning artefacts to the individual learner; for example, tests and performance evaluations can be customised to the learner’s ability, which is a move away from traditional evaluation where all learners do the same test (Willis & Dickinson, 1997:83).

3.4.3.11 Metacognition

The environment should support learners in identifying their knowledge and their skills deficits and in finding strategies, in terms of personal learning goals, to meet those deficits (Vat, 2001:326). This enables individual learners to perform a self-analysis of their learning strategies.

3.4.3.12 Authentic learning

Authentic learning environments can be achieved by making use of real world problems and issues relevant to the learner (Khan, 1997:15). Content that is delivered should be connected to the learners' prior knowledge (Wein et al, 2000).

The discussion of these twelve aspects gives some implicit guidelines and suggestions for features of web-based learning environments. The next section addresses practical issues in the design and development of WBL sites.

3.5 Practical Development of Web-Based Learning Sites

Apart from general issues relating to the design of WBL environments, such as those in Section 3.4.3, guidelines specifically generated for Web design are important in the development of these environments. This section addresses some practical issues. More such will be discussed in Section 5.3.5, in form of heuristics for website design.

Although there is much material on guidelines for developing general Web pages, few sources relate specifically to the design of websites for teaching and learning (Maddux & Johnson, 1997:5). In order to develop appropriate web-based learning environments the developer should abide by certain guidelines. Categories of such guidelines are listed, followed by the description of each in the subsequent subsections:

1. Authority and identity;
2. Content;
3. Navigation, organisation and structure;
4. Interactivity;
5. Language;
6. Graphics; and
7. Help.

3.5.1 Authority and identity

An author of a resource must be of reputable authority. He/she must have legitimate expertise and be well regarded in the academic or industrial field. His/her credentials, contact details and details of who funded or sponsored the site should be provided (Powell, 2001:44).

3.5.2 Content

Content is the information provided on the site. Good content should be engaging, relevant, appropriate and clear for the site users (Sinha, Hearst, Ivory & Draisin, 2001). Web material must not have biases, such as racial and gender biases since these may offend certain users (learners in case of WBL applications). Material should be updated regularly; furthermore, every document should show the dates when it was created and updated, and its full citation. This gives credibility to the site content. It is also important that all content is backed up regularly so that data can be recovered and the site restored if it is destroyed, for example, the destruction of data by a virus (Powell, 2001:44). Clear guidelines should be provided for observance of copyright law in order for the users to know which material is copyrighted and which is not (Maddux & Johnson, 1997:5).

3.5.3 Navigation, organisation and structure

Navigation on a website, and the organisation of its components and the relationship between them, should be simple. Users should always know where they are within the hierarchy of pages. There should not be more than five hierarchical levels. Each page or document should be clearly labelled with a means to return to the home page. For WBL sites, there should be a link to the educational institution. All links should be visible, accurately described, understandable and up to date. The proper page length should be determined so that scrolling is minimised. Icons should represent exactly what they intend to represent. This is because icons are graphical or symbolic representation of concepts (Maddux & Johnson, 1997:5; Powell, 2001:44; Wein et al, 2000). Links should be to other pages, but not to points within the same page since the latter may confuse the learner. Too many links on the same page may also confuse the learner. The use of '…click here' for links should be avoided and instead the title of the destination page should be used (Jones & Farquhar, 1997:241). Simplified or standard mnemonics and icons should be used to enhance navigation and learning. User path maps should be modified and highlighted to indicate the path that the learner has travelled and learning path choices. Different colours could be used in such a case. However, the number of colours should be limited (Hedberg et al, 1997:51). To show progress made, a light red colour or other contrasting hue should be used to show links that have been accessed (Jones & Farquhar, 1997:241).

In terms of organisation, related information should be placed together; for example, all assignments should be grouped together (Powell, 2001:44). Techniques such as chunking, overviews, and maps can be used to provide structure cues to simplify information structure. Important information should be placed at the top of a page since users do not like scrolling to find information (Jones & Farquhar, 1997:241). Headers or links with unfamiliar, confusing text result into major usability problems (Blackmon, Kitajima & Polson, 2005:34)

3.5.4 Interactivity

This refers to the way the site allows users to perform tasks. It involves more than sound effects and flash animation, for the site should allow for easy input and give simple understandable outputs. The site should provide features such as search facilities and chat rooms to enhance its interactivity (Sinha et al, 2001).

3.5.5 Language

Professional language that follows the basic rules of grammar and punctuation, without spelling or syntactical errors, should be used (Maddux & Johnson, 1997:5; Wein et al, 2000). Special consideration should be made for the disabled who may be colour blind or who may need larger fonts to read the text (Maddux & Johnson, 1997:5; Powell, 2001:44).

3.5.6 Graphics

There should be options to load pages or content without any graphics, with minimum graphics and with maximum graphics to allow for easy access by users with different bandwidth and other hardware capabilities. Different pages can be combined in a single document that is suitable for downloading or printing. This makes it easier to keep the different individual pages short, so as to minimise scrolling (Jones & Farquhar, 1997:243). Though some designers urge that a lot of graphics and animation attract users' attention, a limited number of special effects should be used since they may distract users as they perform required tasks (Lazar, 2003:722) and require high bandwidth that may not be available to some users (Powell, 2001:44).

3.5.7 Help

Apart from online help, there should be a section for troubleshooting, frequently-asked questions (FAQs), glossaries and bibliographies (Wein et al, 2000). In addition to these, the system should provide clear error messages accompanied by the procedure to fix the error (Powell, 2001:44).

A number of guidelines appropriate for web-based learning environments have been identified in Sections 3.4 and 3.5. These guidelines are seen as part of the basis from which criteria can be derived for the evaluation of web-based e-learning applications in a tertiary institution. This is done in Chapter 5.

The next section discusses the benefits and challenges of WBL environments.

3.6 Benefits and Challenges of Web-Based Learning

Though there are a number of benefits associated with web-based learning, challenges exist on how best to use the Web for learning (Alessi & Trollip, 2001:372). The next section identifies the benefits, followed by a section that discusses the challenges.

3.6.1 Benefits of web-based learning

Many benefits of WBL have been identified in Section 3.4.1 in the process of discussing the importance of this environment of learning. Taking cognisance of this, this section summarises the benefits of WBL, as proposed by various authors.

According to Starr (1997:8), the benefits of the Web as an educational tool for instructional design are derived from the following:

- **Hypertext**: This provides a simple form of interaction that enables user control of information. By clicking on a hypertext link, learners can access other pages or images, thus obtaining instructional information on related sites and gaining multiple perspectives on issues and multiple modes of presentation.
- **Delivery of multimedia**: A graphical browser can enable a learner to access text, graphics, video and animation materials on the Web. These can be delivered to many users, with a once-off production cost, without decline in quality due to repeated use.
- **True interactivity**: Apart from static Web pages and Web links, interactive pages can enable exchange of information between the user and the server.
- **Cross platform distribution**: Computer-based instruction, once developed, can be distributed to, and used by, anyone regardless of the platform, such as Macintosh, DOS or Windows.
- **Seamless integration**: Parts of the lessons can be integrated in a seamless way so that different parts of the same lesson may be accessed from different sources. For example, in a Geography lesson, Part One may be about the Kruger National Park in South Africa and Part Two about Serengeti National Park in Tanzania.

- **Ease of updating and expansion**: Websites are dynamic, and updated information may be uploaded rapidly, at any time, resulting in information that is more current than the content of the textbooks.

The following are further benefits of web-based learning (Alessi & Trollip, 2001:398):

- Learners' activities can be easily coordinated. For example, it is easier to post an assignment on the Web for all learners, than to print and distribute the assignment, on-site or by distance learning.
- Learners can easily access learning material at their convenience while at an educational institution, at home or at work. World-wide access is also possible.
- It is easy for instructors to supplement their learning material with Web resources.
- Opportunities for learning are created; for example, foreign language learning can be accomplished for a worldwide audience via the Web.
- It facilitates communication among learners and educators, because learners can communicate with the educator or among themselves.

WBL has the following benefits particularly related to its embedded communication facilities (Jolliffe et al, 2001:11):

- Learners can form both informal and formal web-based learning communities;
- It supports collaborative problem-based learning; and
- It can present real-time content using video conferencing, video streaming and discussion rooms.

3.6.2 Challenges to web-based learning

Users of web-based learning should not believe that this medium can solve all their educational problems (Alessi & Trollip, 2001:397). Most of the challenges associated with web-based learning are due to technical limitations of computers and the Internet. Such problems should decrease as new information and communication technologies develop (Jolliffe et al 2001:12). The problems can be categorised as follows:

1. General website problems; and
2. Problems specific to WBL sites.

The problems in each of these categories are listed in the next two subsections.

3.6.2.1 General website problems

Starr (1997:8) and Alessi and Trollip (2001:397) identify the following challenges that apply to Web use in general:

Starr

- Different browsers and platforms may display the pages differently. For example, what was designed as a single page to fit on one screen may be oversized on a user's computer, so that he/she has to scroll vertically or horizontally.
- The user may override some of the designer's display features such as font size and background colour, since he/she has control of some of them.
- The status line of the browser shows the path and filename of the linked page. This can lead to a user tampering with file contents and to other data security risks.
- Once a given link has been followed, it changes colour on the user's screen. This means that others using this computer will not only know what was done by previous users, but may think that he/she has used certain links when in fact he/she has not.
- Transmission times of information, particularly graphics, sound or video, over the Internet or local area network (LAN) can be very slow. This can lead to user frustration and distract them from learning.
- The user may download certain copyrighted text or image file without permission.

Alessi and Trollip

- Because of its size, due to the existence of a vast number of websites, and the complexity of navigation and searching, novice, and even experienced users of the Web can become lost and frustrated.

- Since websites are ever changing, with pages dynamically appearing and disappearing, users cannot depend on them for constant content.
- Since there is little quality control of the Web, some of its information cannot be trusted.
- Since the Web is also used by criminals and fraudsters with unscrupulous intentions, some institutions or parents avoid connectivity for fear that their learners or children will be exposed to undesirable content.

3.6.2.2 Problems specific to WBL sites

The problems identified above are experienced on any website. However, there are problems peculiar to the web-based learning sites, including the following (Jolliffe et al, 2001:12):

- WBL is relatively expensive to establish, compared to other learning environments.
- The content designers should have some background experience in computer-based learning in order to design effective learning material.
- Limitation in bandwidth creates problems when downloading or uploading graphically-intense material. For some educational purposes, such graphics may be essential.
- Learners are sometimes required to buy expensive state-of-the-art computers and the most up-to-date browsers.
- Training is required for both learners and facilitators. Facilitators need to be trained on how to develop, administer and facilitate web-based courses and learners need to know how to use the material in order to learn.

The problems experienced in WBL environments should be seen as challenges that will be overcome with advances in ICT, as stated at the beginning of this section (Section 3.6.2). Furthermore, the problems do not outweigh the benefits such as those identified in Section 3.6.1.

3.7 Conclusion

The Web has captured the interest of educators globally. It is causing educators, from pre-school to graduate school, from the formal sector through to vocational settings in commerce and industry, to rethink the very nature of teaching, learning and training. Advances in network performance and the pervasiveness of the Internet have resulted in its widespread use as an educational medium of instruction for both distance learning and to supplement face-to-face instruction.

Educators and computer scientists have used computers for instructional purposes for the last forty years. Exponential developments have occurred in the evolution of computer technology and in the increase of its availability. Furthermore, this growth has been accompanied by a decrease in price. Educational computing began with a few, large US government-funded projects on mainframes and minicomputers in the 1960s. The introduction of the PC in the 1980s, and the popularity of the Internet and WWW resulted in rapid growth of the use of computers for education and training. Certain learning support models have been proposed to foster the development of e-learning applications based on sound learning theory. Such models take current instructional and learning theories and extract relevant elements and dimensions. Designers of interactive multimedia technologies should take cognisance of these models and theoretical frameworks. In this chapter, various aspects and guidelines based on current learning theories for effective learning, and closely associated with learning support models, have been identified. In the design and evaluation of e-learning applications, the aspects covered in this chapter such as the varying forms of e-learning, the associated methodologies, the underlying theories and models of instructional design, as well as the principles and guidelines, should all be borne in mind.

There are clear benefits associated with web-based learning, as well as many challenges on how to use the Web optimally for learning and teaching. Many of them, such as the aspect of bandwidth are likely to dissipate as ICT develops.

E-learning applications are software systems. The usability of any software system will influence the way the system is used. The next chapter addresses HCI perspectives and discusses usability of applications in general and e-learning applications in particular. The main usability evaluation methods are also described and compared.

Chapter 4: Usability Evaluation: Principles and Methods

4.1 Introduction

Human Computer Interaction (HCI) is a multidisciplinary field concerned with the design, evaluation, and implementation of interactive computer systems for human use and with the study of major phenomena surrounding them (Preece, Rogers & Sharp, 2002:8). Dix, Finlay, Abowd and Beale (2004:124) add that the main focus in HCI is how the human uses the computer as a tool to perform, simplify or support a task. *Usability* is a key issue in HCI since it is the aspect which commonly refers to quality of a user interface (Parlangeli et al, 1999:40). As part of development of any software system that meets HCI standards one should evaluate the usability of the system (Reed, Holdaway, Isensee, Buie, Fox, Williams & Lund, 1999:124).

The requirements for usability of any product, including web-based e-learning applications, must be identified if the product to be designed is to meet the user's needs. One role of evaluation is to ensure that there is an understanding of those needs during the development and use of the product (Card, Moran & Newell, 1990:325; Preece et al, 2002:339). Usability evaluation dates back as far as the beginning of HCI. Though usability evaluation methods (UEMs) emerged more than two decades ago and studies have been done to compare such methods, the area is still relatively new and incomplete both as a research topic and as an applied body of knowledge (Hartson et al, 2003:145).

Since this study seeks to determine the extent to which heuristic evaluation (HE) identifies usability problems in web-based e-learning applications, this chapter gives an overview of usability in general and discusses the main usability evaluation methods. This is done firstly, to form a partial basis for the criteria for evaluation of web-based e-learning to be derived in Chapter 5. Secondly, since HE, which is one of the major focus of this study (see Sections 1.1 and 5.1), is described as efficient, inexpensive and easy to use, it is important that other usability evaluation methods, including user query techniques, be addressed as well, so as to obtain the larger picture and to draw comparisons.

This chapter starts with a discussion of HCI in general, and usability as it is understood in the field of HCI. It includes an overview of usability, usability design and usability principles. After that, a discussion of usability evaluation and the different usability evaluation methods (UEMs) is done. Thereafter a comparison of the different evaluation methods is undertaken.

4.2 Human Computer Interaction

As stated in Section 4.1, HCI is a multidisciplinary approach to the design, evaluation, and implementation of interactive computer systems for human use and the related human aspects (Preece et al, 2002:8). Dix et al (2004:124) point out that in HCI, it is important to understand models of interaction between the computer and the human as well as interaction styles and the ergonomic issues in such interactions. These three aspects will briefly be discussed in the next subsections.

4.2.1 Models of interaction

Norman's Action Cycle Model (Norman, 1988:47-48) is one of the most influential models of interaction in HCI (Dix, Finlay, Abowd & Beale, 1998:105) that explains human-computer interactions (Shneiderman & Plaisant, 2005:87). The model uses an interactive cycle that has two major phases: execution and evaluation, which can be subdivided further into the subphases as shown in Table 4.1.

First, the user forms a goal that is transformed into more specific intentions. The actual actions to be taken are identified and then executed, thus completing the execution phase. The evaluation phase commences as the user perceives and interprets the resulting system state. If the system state reflects the user's goal then the computer has done what is required and the interaction has been successful, otherwise the user must formulate a new goal and repeat the cycle. This model shows that if the actions allowed by the system correspond to those intended by the user, the interaction will be effective.

	• Establishing the goal
Execution	• Forming the intention • Specifying the action sequence • Executing the action
Evaluation	• Perceiving the system state • Interpreting the system state • Evaluating the system state with respect to the goals and intentions

Table 4.1: Norman's Action Cycle model phases and subphases (Norman, 1988:47-48)

The criticism of this model is that it concentrates wholly on the user's view of the interaction and does not try to deal with the system's communication through the interface. The interaction framework extends the model and deals with this problem (Dix et al, 1998:106).

The general Interaction Framework, Figure 4.1, is a description of interaction that explicitly includes the system, broken down into four major components: the *system* (S), the *user* (U), the *input* (I) and the *output* (O).

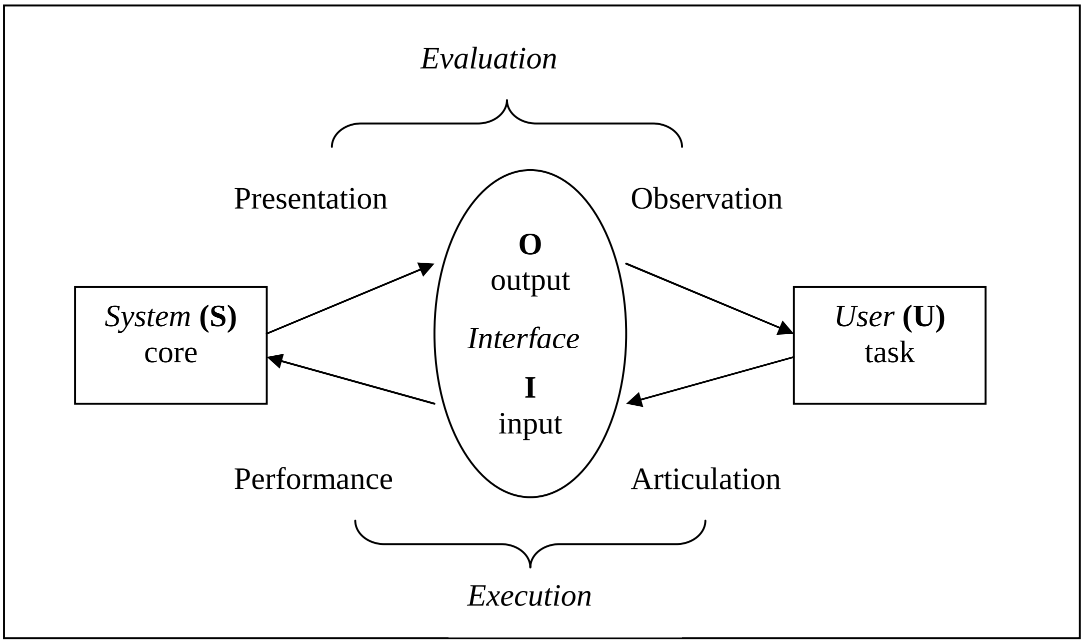

Figure 4.1: Interaction Framework, showing transitions (Dix et al, 1998:106)

The input and output together form the *interface*. There are four steps in the interactive cycle, as depicted in the figure, each corresponding to a transition from one component to another.

The *user* begins the interaction with the formulation of a goal and a *task* to achieve that goal. This must be articulated as an *input* to the system. The input language is translated into a *core* language in the form of an operation performed by the *system*. The system transforms itself into a new state, the *output*, which must be communicated and presented to the user. It is up to the user to make an observation of the output and assess the results of the interaction relative to the original goal, and this ends the interactive cycle. Articulation and performance form the execution phase and presentation and observation form the evaluation phase of the interaction (Dix et al, 1998:106-7).

4.2.2 Interaction styles

Interaction is a dialogue between the computer and the user. The choice of interface style determines how well and how effectively this dialogue takes place. The most common interface styles are (Dix et al, 1998:115-6):

- **Command line interface**: this provides a means of entering instructions to the computer by functional keys, single characters, abbreviations or whole-word commands.
- **Menu:** user options for the user are displayed on a screen and can be selected using the mouse, or numeric, alphabetical or arrow keys.
- **Natural language**: words – written or spoken – in natural language are used as input to the computer.
- **Question/answer and query dialogue**: the user gives answers to a series of closed questions in order to be led step-by-step through an interaction.
- **Form-fills and spreadsheets**: the user is provided with a display, resembling a paper form, with slots to fill in.
- **WIMP (windows, icons, pointers and menus):** based on windows interfaces such as those used in Microsoft Windows™.

- **Point-and-click**: consists of objects such as icons, words, buttons that are clicked to produce an action.
- **Three-dimensional interface**: uses three-dimensional (3-D) effects in interfaces, such as use of virtual reality.

The most common current environments for interactive computing are based on WIMP, especially in the PC and workstation arenas. However, in many multimedia applications and in Web browsers, most actions can be implemented by a single click of the mouse button. This point-and-click interface style is closely related to the WIMP style. The philosophy for point-and-click is simpler than that of WIMP and is more closely tied to the idea of hypertext. The choice of interface style, and the context in which it is used determines the nature of interaction between the human and the computer (Dix et al, 1998:116).

Preece et al (2002:60) point out that the recent trend has been to promote interaction paradigms beyond the desktop, due to the advances in wireless, mobile and handheld technologies. Some of the paradigms proposed by researchers to guide future interaction design and system development include:

- Ubiquitous computing: this is technology embedded in the environment, often unnoticed by the user;
- Pervasive computing: seamless integration of technologies; and
- Wearable computing: technology that can be worn.

4.2.3 Ergonomics

Ergonomics, or ‘human factors’, is the study of the physical characteristics of interaction, which includes the following (Dix et al, 1998:110):

- How the controls are designed;
- The physical environment in which the interaction takes place; and
- The layout and physical qualities of the screen.

The main focus of ergonomics is user performance and how the interface enhances or works against the performance. Ergonomics includes aspects of human psychology and constraints. Some of the issues dealt with in ergonomics that are important in human computer interaction are (Dix et al, 1998:111):

- Arrangement of controls and displays;
- The physical environment;
- Health issues; and
- The use of colours.

4.3 Usability

4.3.1 Usability defined

Before defining usability, it is important to understand its framework. In 1991, Shackel proposed a usability framework, illustrated in Figure 4.2, consisting of four principal components that exist in any system comprising technology and human users.

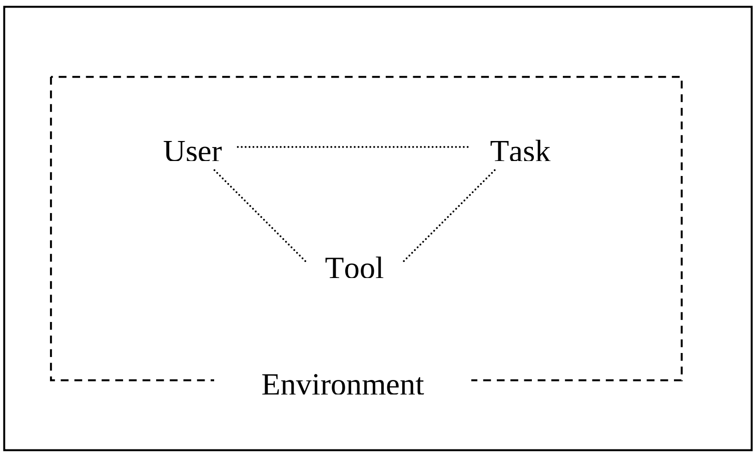

Figure 4.2: The four principal components in a human-machine system (Shackel, 1991:23)

The components are the user, task, tool and environment. In HCI the *tool* refers to the computer system, both hardware and software, and the *task* refers to the processes, such as editing a letter, that a *user* can perform with the computer system. All this is done within a particular context, the *environment* (Shackel, 1991:23).

In support of this framework, the following factors should be considered when performing any evaluation (Preece, 1993:108):

- The experience level of users,
- The type of task being undertaken,
- The system being used, and
- The environment in which the study takes place.

Using Shackel's framework, usability was formerly defined as:-
"the capacity in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfil the specified range of tasks, within the specified range of environmental scenarios" (Shackel, 1991:24).

This definition has led to the more recent definitions of usability, as described in the next paragraph; they do not necessarily conflict with the former, but explicitly state that 'user satisfaction' should be taken into consideration and the issue of giving 'specified training and user support' left out. However, the more recent definitions are still in harmony with the usability framework as it stood. The next paragraph gives some of the more recent definitions of usability.

As stated in Section 1.1, the International Standards Organisation (ISO) defines usability as:
"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context" (ISO, 1998).

A number of researchers and practitioners use this as the standard definition of usability (Aborg, Gulliksen & Lif, 2003:456; Costabile et al, 2005:2; Geis, 2002; Holzinger, 2005:71).

In agreement with this definition, Karoulis and Pombortsis (2003:91) define the usability of a system as its ability to function effectively and efficiently, while providing subjective satisfaction to its users. Usability can also be defined as the degree to which a user can easily learn and effectively use a system to finish a job (Jones, 2000:343). Preece, Rogers, Sharp, Holland and Carey (1995:15) point out that human factors, the activities or tasks, the efficiency and effectiveness of the system, and the safe interaction with the user must be considered, when analysing the usability of a system. The human factors include an understanding of psychological, ergonomic, organisational and social aspects.

In line with the ISO definition, one can conclude that the usability of the system will comprise learnability, effectiveness, efficiency and satisfaction (Hugo, 1998) with which specified users can achieve specified goals in a particular environment, where:

- **Learnability** measures the time taken to get accustomed to the system and its operation and how easy it is to remember operational details;
- **Effectiveness** measures the accuracy and completeness of the goals achieved;
- **Efficiency** measures the accuracy and completeness of goals achieved relative to the resources, for example, human time and effort used to achieve the specified goals; and
- **Satisfaction** measures the comfort and acceptability of the system to its users and other people affected by its use.

Holzinger (2005:72) and Karoulis and Pombortsis (2003:91) list certain characteristics associated with the usability of a system. The system should be:

- **Easy to learn:** the user can work quickly with the system;
- **Efficient to use**: high productivity can be obtained from the system by a user who has learnt the system;
- **Easy to remember**: a casual user can return to using the system after some period without having to relearn it;
- **Not conducive to errors**: a user does not make many errors during the use of the system, or when he/she does do so, he/she can easily recover; and

- **Pleasant to use**: the user gets subjective satisfaction from using the system, since he/she enjoys using it.

When dealing with usability, *ease of use* and *effectiveness* should ideally be defined in quantifiable metrics such as (Chapanis, 1991:363):

- **Ease of start up**: the time taken to open an application, or to install a program and start using it;
- **Ease of learning:** the time required to learn how to perform a set of tasks with the system;
- **Error scores**: the number of errors committed or the time taken to correct errors;
- **Functionality**: the number of different things the program can do; and
- **Users' rating of ease of use**: though users' perceptions cannot be observed, they can be measured by their ratings.

Usability is essential in the development of e-learning applications. If they are not easily usable, the learner will spend too much time trying to understand system functionality rather than engaging with the content (Costabile et al, 2005:2). The interface of the application should nearly be virtually invisible to the learner (Veldof, 2003:129). This issue is discussed in more detail in Section 5.1.

According to the discussion in this section so far, usability relates to having a system which is easy and safe to use, and satisfies user requirements in a particular environment. Apart from the efficiency and effectiveness of the system, and the need for user satisfaction, the three focus areas of usability are: the user, the task and the environment. These three are dealt with in the next section, under usability design, after which the usability principles, which include learnability, flexibility and robustness, are discussed.

4.3.2 Usability design

Shneiderman and Plaisant (2005:100) state that usability design should be based on careful observation of current users, refined by thoughtful analysis of task frequencies and sequences.

The design must be validated through early, careful and thorough prototypes, usability and acceptance tests. The goals for validating user interface design must include the following measurable human factors that can be used for assessing usability (Hoffer, George & Valacich, 1999:538; Shneiderman & Plaisant, 2005:16):

- Time to learn;
- Speed of performance;
- Rate of errors by users;
- Retention over time; and
- Subjective satisfaction.

4.3.2.1 User analysis

User analysis, according to Shneiderman (1998:67), requires understanding of the intended users, including, age, gender, physical abilities, education, culture, training, motivation, goals and personality. These factors can assist the designer in knowing whether the user is a novice, knowledgeable or an expert. After performing user analysis, task analysis must be done.

4.3.2.2 Task analysis

Preece et al (1995:410) describe task analysis as having the goal of eliciting descriptions of what people do, representing those descriptions, predicting difficulties and evaluating systems against usability or functional requirements. Task analysis is concerned with what people do to get things done. Tasks should be designed so as to be meaningful and desirable to the user.

4.3.2.3 The environment

The main goal of usability design is to focus system design on the users, the tasks they must perform, and the environment in which they will work. Good usability design should result in efficient and effective systems, which satisfy user needs.

4.3.3 Usability principles

Dix et al (1998:144) state that principles of interaction between the human and the computer are independent of the technology used, for they depend largely on a deeper understanding of the human element in the interaction.

Though it is very difficult to produce a comprehensive catalogue of usability principles, a general classification can be given, that can be extended as more knowledge is accumulated in this area. The principles of usability can be divided into three main catalogues (Dix et al, 2004:260; Galitz, 1997:89):

- Learnability;
- Flexibility; and
- Robustness.

These are discussed in the next subsections.

4.3.3.1 Learnability

Learnability deals with the ease with which new users can begin effective interaction and achieve maximum performance. The specific principles that support learnability and their corresponding meanings are given in Table 4.2.

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

Table 4.2: Summary of principles affecting learnability (Dix et al, 2004:261)

4.3.3.2 Flexibility

Flexibility is the multiplicity of ways in which the user and system exchange information. The specific principles that support flexibility and their corresponding meanings are given in Table 4.3.

Principle	**Definition**
Dialogue initiative	Allowing the user freedom from artificial constraints on the input dialogue imposed by the system
Multi-threading	Ability of users to support user interaction pertaining to more than one task at a time
Task migratability	The ability to pass control for the execution of a given task so that it becomes either internalised by user or system, or shared between them
Substitutivity	Allowing equivalent values of input and output to be arbitrarily substituted for each other
Customisability	Modifiability of user interface by the user or the system

Table 4.3: Summary of principles affecting flexibility (Dix et al, 2004:266)

4.3.3.3 Robustness

Robustness is the level of support provided to the user in determining successful achievement and assessment of goals. The specific principles that support robustness and their corresponding meanings are given in Table 4.4.

Principle	**Definition**
Observability	Ability of the user to evaluate the internal state of the system from its perceivable representation
Recoverability	Ability of a user to take corrective action once an error has been recognised
Responsiveness	How the user perceives the rate of communication with the system
Task conformance	The degree to which the system services support all of the tasks the user wishes to perform and in the way that the user understands them

Table 4.4: Summary of principles affecting robustness (Dix et al, 2004:270)

Given the principles of usability, evaluation of a system can be performed to find out how well it meets the principles. Usability principles and usability evaluation are closely related.

4.4 Usability Evaluation and Classification of UEMs

4.4.1 What is usability evaluation?

Usability evaluation is concerned with gathering information about the usability or potential usability of a system in order either to improve its interface or to assess it. The aim is to determine the effectiveness or potential effectiveness of an interface in use or to provide a means of suggesting improvements to it (Preece, 1993:108). More specifically, the main goals of evaluation are (Dix et al, 2004:319):

- To assess the extent of the system functionality;
- To assess the effect of the interface on the user; and
- To identify the specific problems with the system.

Evaluation thus involves the user, the tasks, and ease of use of the system.

In line with the issues discussed in defining usability in Section 4.3.1, the usability issues that need to be investigated are efficiency, effectiveness and satisfaction. Efficiency is concerned with the ease of learning and use of a system. Effectiveness deals with the ability of a system to perform tasks comprehensively and accurately. Satisfaction refers to the ability of a system to successfully complete tasks (Genise, 2002).

Though there are a number of methodologies and models that support the design of usable interactive systems, there is a need to assess the design and test the systems to ensure that they actually behave as expected and meet the requirements of the user. This means that evaluation should not be considered as a single phase in the design or assessment of a system but, ideally, be conducted throughout the systems development life cycle (Dix et al, 2004:319).

As has been stated in Section 1.1 and will be discussed in Section 4.10, various usability evaluation methods (UEMs) exist. While some of them involve users directly, others call indirectly on an understanding of users' needs and psychology (Preece et al, 2002:318). The next section concentrates on defining, identifying and classifying the major evaluation methods.

4.4.2 Formal definition of a usability evaluation method

"A usability evaluation method is a systematic procedure for recording data relating to end-user interaction with a software product or system" (Fitzpatrick, 1999). After the data has been recorded, it can be analysed and evaluated in order to determine the level of usability of the system or product.

A number of authors have different usages of the use of the terms 'methods' and 'techniques' in the field of usability evaluation. The terminology in this field tends to be loose and often confusing in that what some authors call 'techniques' others call them 'methods' and vice-versa (Preece et al, 2002:340). Sometimes a number of techniques are taken to be a subset of a particular method. For example, if one considers *expert-review evaluation* as one of the evaluation methods, one could have *heuristic evaluation* and *cognitive walkthrough* as techniques used within this method (Shneiderman, 1998:126). However, sometimes the method and the techniques are one and the same. For example, *experimentation* might be the only technique included in the experimental evaluation method. However, in line with the definition given in the last paragraph, since a method is '*a systematic procedure for recording data'* and any technique would aim at the achieving this, the terms 'methods' and 'techniques' will generally be used synonymously in this study. This view is supported by Preece et al (2002:340) who suggest that in order to eliminate any confusion there should be no distinction between these two terms, i.e. they should be considered synonymous.

4.4.3 Approaches to evaluation

According to various authors, different approaches to evaluation can be classified according to whether end users will be involved or not, the stage of the system development, and the place where the evaluation will be carried out. These three are briefly discussed in the next three subsections.

4.4.3.1 User involvement

Lewis and Rieman (1994) suggest that the two major approaches to evaluation should be evaluating the system with users and without users. In support of this approach, Preece (1993:121) points out that methods that do not involve end users can be suitable for evaluation of certain systems. However, other evaluation approaches such as *contextual inquiry* that directly involves users, should, where possible, be used, independently or in addition to those without users. This results in acquisition of information from the users about the usability problems of systems in their natural environment, as users and evaluators collaborate in order to identify usability problems.

4.4.3.2 Formative and summative evaluation

Faulkner (2000:138) describes two major types of evaluation: *formative evaluation*, which is conducted during system development in order to formulate and refine the design of the system, and *summative evaluation*, which is conducted on existing functioning systems, with the purpose of assessing the impact, usability and effectiveness and the overall performance of the user and the system. Preece (1993:108) argues that evaluation is closely related to the design and development of a system and that it can be done during any of the phases of system development, with formative evaluation performed prior to implementation, in order to influence the product that will be produced, and summative evaluation done after the implementation with the aim of testing the proper functioning of the final system. In short, formative evaluation is used in *adapting* a system, while summative evaluation is often used prior to *adopting* a system, or for selection between different systems. *Quality control*, in which a system is reviewed to determine whether it meets its specification, and *testing*, which is done in order to determine whether a product meets prescribed national or international standards (such as those by the International Standard Organisation), are also forms of summative evaluation.

4.4.3.3 Place of evaluation

Dix et al (2004:327) distinguish evaluation styles according to their location. There are evaluations carried out in the laboratory environment, and evaluations conducted in the natural environment, i.e. *ethnographic* evaluations. Evaluation studies conducted within the laboratory are sometimes done without the involvement of the user, especially when the system has not yet been implemented. However, users can also be participants in such studies, for example, in formal usability testing under controlled conditions in usability laboratories. Evaluations done in the workplace take the designer or evaluator into the user's work environment in order to observe how the system is used by the actual users conducting their everyday duties.

Apart from the different styles or approaches to evaluation that have been identified, a number of methods exist. These are identified in the next section.

4.4.4 Classification of usability evaluation methods

There are a number of approaches to the classification of usability evaluation methods (Huart, Kolski & Sagar, 2004:188). This section starts with an overview of classifications given by some of the leading researchers and authors in the field of HCI. The information is summarised in Table 4.5, which was synthesised by the present author. It forms a basis for a *Derived classification* that is discussed in detail in Sections 4.5 to 4.9. The authors whose classifications are given in Table 4.5 are Preece (1993:118), Shneiderman and Plaisant (2005:140), Dix et al (2004:361), and Preece et al (2002:345). Their classifications are briefly elaborated in Sections 4.4.4.1 to 4.4.4.4. Each column of the table lists the different methods identified by a particular author, sequenced in such a way that each row of the table presents the methods that are generally the same or similar, in the opinion of the present author. With reference to the nomenclature given by the different authors, each row has been assigned a name by the present author under the Derived classification.

As stated in the last paragraph, the classification of usability evaluation methods corresponds to the aspects of the literature survey to be presented in Sections 4.5 to 4.9:

- **Empirical evaluations**(Section 4.5)
- **Model-based evaluations** (Section 4.6)
- **Observational methods** (Section 4.7)

- **Query techniques** (Section 4.8)
- **Expert evaluation methods** (Section 4.9).

Derived classification	**Preece (1993:118)**	**Shneiderman and Plaisant (2005:140)**	**Dix et al (2004:361)**	**Preece et al (2002:345)**
Empirical evaluations	Experimental	Controlled psychologically-oriented experiments	Empirical methods: Experimental evaluations	Experiments or benchmark tests
Model-based evaluation methods	Analytical methods	Acceptance testing	Model-based evaluations	Interpreting naturally-occurring interactions
Expert evaluation methods	Expert	Expert reviews	Heuristic evaluation Cognitive walkthrough Review-based evaluation	Predicting the usability of a product
Observational methods	Observational	Evaluation during active use Usability testing and laboratories	Observational techniques Monitoring techniques	Observing and monitoring users' interactions
Query techniques	Surveys	Surveys	Query techniques	Collecting users' opinions

Table 4.5 Classification of usability evaluation methods

It is important to note that the techniques, as given by the different authors, under each Derived classification are not absolute; in fact, some techniques could be placed in different categories. For example, acceptance testing, as identified by Shneiderman (1998:123), cannot be easily placed in any of the categories. Although it is based on predicted, precise, measurable criteria (Shneiderman, 1998:144), similar to model-based evaluations, it is also similar to experimental (empirical) evaluations even though it is performed in a normal working environment, where control of variables is not the same as it would be in experiments. Another reason is that some of the evaluation methods are not mutually exclusive. For example, interviews may be conducted on their own, as a query technique, or as a sequel to laboratory testing.

Of the five derived categories, in Table 4.5, analytical and expert evaluation methods are more suitable for evaluations carried out prior to implementation of the system before an operational system exists, and the rest afterwards, though some of the methods can be used at any phase of the system development. It is also important to note that most of the methods used after the implementation of the system are user-centred evaluations that entail direct feedback from the user (Dix et al, 1998:416).

The following four sections briefly describe the usability methods as given by the different authors in Table 4.5. The numbering of the categories is not for ranking purposes – they could be in any other order. The descriptions are brief, since a detailed survey of most of the methods is given in Sections 4.5 to 4.9.

4.4.4.1 First category of usability evaluation methods: Preece

Preece (1993:109) categories the evaluation methods as follows:

- **Analytical evaluation**: formal or semiformal interface descriptions to predict user performance;
- **Expert evaluation:** based on assessment of the system by domain experts;
- **Observational evaluation**: observation or monitoring of users' behaviour as they use the system;
- **Survey evaluation**: elicitation of users' subjective opinions of the usability of the system; and
- **Experimental evaluation**: scientific experimental practices to test hypotheses about the usability of the system.

4.4.4.2 Second category of usability evaluation methods: Shneiderman

This section lists the major usability evaluation methods identified by Shneiderman and Plaisant (2005:140). The techniques under each of the categories are identified without describing them, since this study concentrates on the major usability evaluation methods in HCI. *Acceptance testing* is the only exception – it is described in some detail, since it could not be placed in any category in Table 4.5. However, the other categories are, in general, covered in detail in Sections 4.5 to 4.9 in this chapter. The aim here is to show the variation of techniques within each category. The categories are as follows:

- **Expert reviews**: include evaluation techniques such as:
  - Heuristic evaluation;
  - Guideline review;
  - Consistency inspection;
  - Cognitive walkthrough; and
  - Formal usability inspection.
- **Usability testing and laboratories**: techniques in this category include:
  - Think aloud;
  - Video taping; and
  - Field tests using mobile equipment.
- **Surveys**: include evaluation techniques such as:
  - Paper surveys with questionnaires;
  - Online surveys with questionnaires; and
  - Questionnaires for user interaction satisfaction.
- **Acceptance testing:** This technique uses objective and measurable goals that must be met by the system, for usability evaluation. Instead of using subjective criteria like ‘user friendliness’, measurable criteria usually set by the customer, such as ‘number of errors made by a first-time novice user in the first two hours of use’, are used to determine whether a system is acceptable or not. If not met, the system is reworked until they are met. The central role of acceptance testing is not to detect flaws in the system, but rather to verify that the system adheres to the requirements (Shneiderman & Plaisant, 2005:163). Some of the measurable criteria, to be taken into account during usability evaluation include (Shneiderman & Plaisant, 2005:162):
  - Time for users to learn specific functions;
  - Speed of task performance;
  - Rate of errors by users; and
  - User retention of commands over time.

- **Evaluation during active use:**
  - Interviews and focus-group discussions;
  - Continuous user-performance data logging;
  - Use of online telephone consultants;
  - Online suggestion box or trouble reporting;
  - Using online bulletin boards or newsgroups; and
  - Feedback by newsletters and conferences.
- **Controlled psychologically-oriented experiments**
  - Experiments.

4.4.4.3 Third category of usability evaluation methods: Dix et al

Dix et al (2004:361) categorises the evaluation methods as follows:

- **Cognitive walkthrough**: expert evaluators walking through the system tasks and recording usability problems;
- **Heuristic evaluation**: same as expert evaluation in Section 4.4.4.1;
- **Review-based evaluation**: uses results from previous studies in evaluation as evidence to support or refute aspects of a user interface;
- **Model-based evaluation**: use of cognitive and design models to evaluate interfaces.
- **Empirical methods**: experimental evaluation;
- **Query techniques**: questionnaires and interviews with users and stakeholders;
- **Observational techniques**: same as observational evaluation in Section 4.4.4.1; and
- **Monitoring techniques**: evaluation through monitoring of physiological responses of users, for example, by tracking eye movement to determine which areas of an interface users find easy or difficult to understand.

4.4.4.4 Fourth category of usability evaluation methods: Preece, Rogers and Sharp

Preece et al (2002:345) identify the kinds of evaluation as:

- **Observing and monitoring users' interactions**: same as observational evaluation in Section 4.4.4.1;
- **Collecting users' opinions**: same as surveys in Section 4.4.4.1;
- **Experiments or benchmark tests**: evaluation using experiments as in Section 4.4.4.1;
- **Interpreting naturally-occurring interactions**: same as model-based evaluations in Section 4.4.4.3; and
- **Predicting the usability of a product**: same as expert evaluation in Section 4.4.4.1.

Although the various authors' classifications are different, they cover similar, overlapping and inter-related areas, hence the present author's grouping of related approaches into rows in Table 4.5.

4.4.5 Heuristic evaluation in the context of other UEMs

This study focuses on the extent to which heuristic evaluation identifies usability problems in web-based learning applications. Due to the multiple UEMs overviewed in this chapter, HE can now be viewed in context. In Section 1.1 it is stated that HE is the most widely used evaluation method, since it is effective, inexpensive, easy and fast to perform, which is one of the rationales for undertaking this study. It is important that all the major evaluation methods be studied to justify this rationale and to make a comparison. The next five sections, 4.5 to 4.9, describe and discuss in some detail the major usability evaluation methods identified in Table 4.5, under the heading Derived classification.

4.4.6 Informed consent by participants

Evaluation participants – end users or expert evaluators – give time and trust to the evaluation process. This goodwill should not be abused by a researcher. In all forms of evaluation, it is important that evaluations are performed in an ethical manner and that all participants' rights are protected (Preece et al, 2002:352). The following guidelines ensure that this is done (Preece et al, 2002:353, Shneiderman & Plaisant, 2005:147):

- Participants should be informed of the goal of the study, how they will participate and what to expect. Issues like time to be taken, type of data to be collected and how it will be analysed, and the payment to be made, if any, should be clearly communicated to the participants.
- It should be explained clearly that the information – be it demographic, financial, or any other – disclosed or discovered during the evaluation is confidential
- Participants should know that they have the right to stop during any stage of the evaluation if they feel so.
- If participants are to be quoted, the evaluator should seek their permission in advance, promise them anonymity, and offer to avail them with a copy of the report before its distribution.
- Participants should be given an informed consent form to read and sign. The form should explain the aim of the evaluation and any other relevant issues including the fact that participants' personal details and performance will not be made public and will only be used for the stated purpose.

Informed consent applies to the different evaluation methods discussed in Sections 4.5 to 4.9.

4.5 Empirical Evaluation

Empirical, or *experimental*, evaluation is based on the use of scientific experimental methods to test hypotheses about the usability of a system (Preece, 1993:109). This approach to usability evaluation originates from the scientific and engineering fields where experiments have reliably been used for precise measurement of issues of interest for a long time. Academic and industrial researchers in the HCI discipline have discovered that traditional experimental methods can also be used in the study of computer system interfaces (Shneiderman, 1998:149). Although scientific experimentation is usually too expensive, or just not practical, there are certain cases where it is appropriate to apply it for usability evaluation of computer systems (Preece et al, 2002:443).

In this section, the principles of experiments are addressed, followed by a discussion of experiments in HCI and, specifically, empirical evaluation of web-based environments.

4.5.1 How to carry out an experiment

An experiment aims to answer a question or to test a *hypothesis* in order to discover new knowledge. This is done by determining the relationship between two or more values or events known as *variables*. This is normally conducted by manipulating one of them and observing the effect of this on the other. The experimenter normally tries to minimise the effect of other variables that could influence the results of the experiments, by controlling them as much as possible (Johnson, 1992:89; Preece et al, 2002:430). In HCI, the researcher usually manipulates a number of factors associated with the interface of the system and studies their effect on aspects of user performance (Preece, 1993:117).

Dix et al (2004:329) conclude that the main issues that are important for the overall reliability of experiments are the subjects chosen, the variables tested and manipulated, and the hypotheses tested. These are discussed in the next three sections

4.5.1.1 Subjects of an experiment

The subjects refer to the participants in the experiment. The choice of subjects is very important for the success of an experiment. Though it would be ideal to perform the experiment with the actual users, it is not always possible. Because of this, it is vital that the subjects chosen match the typical user population as closely as possible. For example, they should be of similar age and level of education as the actual users. A further issue to consider when choosing subjects is the number of people participating in the experiment, referred to as the sample size. This should not be based on what is convenient, such as the availability of the subjects, but rather on a sample which is large enough to be considered as representative of the population. It is recommended that at least ten subjects take part in a controlled experiment (Dix et al, 2004:329).

4.5.1.2 Variables

In order to test the hypotheses, experiments manipulate and measure two types of variables under controlled conditions. Those that are manipulated are referred to as *independent variables* and those that are measured are referred to as *dependent variables*. Independent variables are manipulated in order to produce different conditions for comparison. For example, in a traditional scientific experiment to determine whether search speed increases as the number of icons on the screen decreases, the researcher may consider screens with five, ten or fifteen icons. The independent variable would be the number of icons and would have three levels. The dependent variables would be the rate of icon selection. These variables must be measurable, must be affected by the independent variables, and must not be affected by other factors, if possible. For example, in the example experiment mentioned in this section, the size of the icons and their colour should remain constant. Some of the common dependent variables in HCI evaluation experiments are the time taken to do a task, the number of errors made, user preference and the quality of user performance. Objective dependent variables, for example, the time to do a task, are easy to measure, but the subjective ones, like user preference, should also be measured against a predetermined scale (Dix et al, 2004:30).

4.5.1.3 Hypotheses

A *hypothesis* is a statement, framed in terms of the independent and dependent variables that predicts the outcome of the experiment. It states that a variation in the independent variable will result in a difference in the dependent variable. An example of a hypothesis would be:

- The search speed for a required icon increases as the number of icons on a screen decreases.

This is the hypothesis that could have been used to carry out the experiment described in the previous subsection (4.5.1.2). The aim of any experiment is to prove that the hypothesis is correct. This is done by disproving the *null hypothesis*, which is the argument that there is no difference in the dependent variable even at different levels of the independent variable. The null hypothesis, in the example given in this subsection, would state that:

- The speed of search is not affected by the number of icons on the screen

(Dix et al, 2004:330).

When performing experimental evaluation, the evaluator should consult a statistician who is knowledgeable about relevant statistical tests, so that data is collected in such a way that it can be analysed to arrive at a valid conclusion (Preece et al, 2002:444).

4.5.2 Experiments in Human Computer Interaction

In applying experiments in the field of HCI, such as performing usability evaluations, the following aspects of this scientific method should be considered (Shneiderman, 1998:149):

- Deal with a practical problem in the context of the theoretical framework;
- State a clear and testable hypothesis;
- Identify a number of independent variables that are to be manipulated;
- Carefully choose the dependent variables that will be measured;
- Select subjects, and carefully or randomly assign subjects to groups;
- Avoid the influence of the biasing factors;
- Apply statistical methods to analyse the data; and
- Resolve the practical problem, refine the theory, and give advice to future researchers.

In line with the above, Preece (1993:117) summarises the approach in three main elements for the planning of experimental evaluations:

- The purpose of the evaluation has to be expressed in such way that what is to be changed, what is to be kept constant and what is to be measured, are clearly stated;
- The hypotheses should be testable; and
- Statistical tests should be performed to check the reliability of the results.

Because it is not always possible to follow all the procedures necessary for an experiment, quasi experiments are instead sometimes used in HCI investigations. A quasi-experiment is similar to an experiment but without all the controls. For example, instead of using randomly assigned groups, one may use natural groups. For instance, if one wanted to study the performance difference of two age groups on a particular system, it would be considered a quasi-experiment since the age groups occur naturally. Another characteristic of quasi-experiments is that the environment may not be controlled. For example, instead of carrying out the experiment in the laboratory, it may be done at work (Atwater & Babaria, 2004).

4.5.3 Empirical usability evaluation of WBL applications

As already stated, despite their reliability, experiments as methods of evaluation in HCI are rare since they are usually very expensive, for, according to Ardito, Costabile, De Marsico, Lanzilotti, Levialdi, Roselli and Rossano (2006:274), they may require sophisticated equipment.

4.6 Model-Based Evaluation Methods

Model-based or analytical evaluation methods enable system designers to analyse and predict expert performance of error-free tasks in terms of the physical and cognitive operations that must be performed by the system. These methods can be carried out even when the interface of the system is represented by formal or semi-formal specification. This makes these methods suitable for usability evaluation in an early phase of system development (Preece, 1993:109). Model-based evaluation refers to the process of using a model of how the users would use a proposed system to obtain predicted usability measures by calculation or simulation (Kieras, 2003:1140).

There are various model-based methods, of which GOMS is the most widely used predictive model in HCI (Preece et al, 2002:449). It is the only generic model described in this study. This section overviews GOMS and discusses how model-based evaluations can be used in WBL applications.

4.6.1 GOMS

GOMS is a generic term which refers to a family of models that vary in their granularity as to what aspects of a user performance they model and for which they make predictions. These aspects include the time needed to do a task and the most effective strategies used to accomplish such a task. The technique is useful in predicting the efficiency and effectiveness of a system in situations where it is difficult to do user testing. This can help designers compare the performance of different interfaces, without the users, long before the actual system is constructed. The two most popular models in this technique are the *GOMS model* and its derivative, the *keystroke level model* (Preece et al, 2002:449), which are described in the next two sections.

4.6.1.1 GOMS model

The GOMS model consists of descriptions of methods required to accomplish specified goals (Preece, 1993:46). GOMS is an acronym for goals, operations, methods and selection, each of which is described as follows (Preece et al, 2002:449):

- **Goals**: the particular states that a user wants to achieve;
- **Operators**: the cognitive processes and physical actions to be performed in order to attain the goals;
- **Methods**: the procedures used to accomplish the goals, and to indicate the exact sequence of the steps required; and
- **Selection rules**: if there is more that one method to perform a given stage of the task, these rules determine which of the methods to select.

In summary, GOMS consists of descriptions of methods needed to accomplish specified goals. *Goals* are what the user is trying to accomplish. They can be defined at different levels of abstractions, from very high level goals such as *Search for a Database design tutorial on the Internet* to a low level, such as *Delete a word*. *Operators* are elementary atomic or discrete perceptual, motor or cognitive actions that are used to accomplish the goals, for example *Click mouse*. Operators are not decomposable and take a measurable time for the user to execute. The *methods* consist of a number of operators a user performs to achieve the goal. A method is the sequence of subgoals and operators the user has internalised as necessary to achieve a desired goal. For example, according to Preece et al (2002:450) one of the methods to accomplish the goal *Delete a word* using the menu option in Microsoft Word™ would involve the following steps:

- **Step 1**. Recall that the word to be deleted has to be highlighted;
- **Step 2**. Recall that the command is ‘cut’;
- **Step 3**. Recall that ‘cut’ is in the edit menu;
- **Step 4**. Accomplish goal of selecting and executing the ‘cut’ command; and
- **Step 5**. Return with goal accomplished.

The operators to use in this method would be:

- Click mouse;
- Drag cursor over text; and
- Move cursor to command.

If more than one method exists to accomplish a goal, then the selection rules determine the appropriate method to choose depending on the context. For example:

- If the word to delete is three lines way from the current cursor location then use the Delete key to delete the word or else use the menu option to delete the word.

This decision is based on the fact that the method one uses depends on how far away the cursor is from the word to be deleted (Hochstein, 2002).

4.6.1.2 Keystroke level model

As mentioned before, the keystroke level model (KLM) is a variation of the GOMS model. Its main difference is that it provides actual predictions of user performance in terms of time. The time required to perform different tasks under different circumstances can be measured and compared. This makes it possible to determine which features of a system are the most effective for performing certain tasks using quantitative data (Preece et al, 2002:450).

The KLM is based on the findings of a number of empirical studies of actual user performance. The results of these studies were used to determine a standard set of approximate times for the main kinds of operators used during a given task. This made it possible to determine the average times it takes to carry out common physical tasks, such as ‘Click a mouse button’, and other aspects of user-computer interaction such as the time it takes a person to decide what to do, or the time it takes the computer system to respond. This makes it possible to calculate the sum of the time required for the operators in the sequence of operations required to perform a task. It, therefore, becomes easy to compare, in terms of time, the most effective approach to performing a task on a particular system, or to compare the efficiency of different system interfaces (Preece et al, 2002:451).

4.6.1.3 Benefits of GOMS

GOMS is one of the most widely used and acknowledged predictive evaluation techniques in HCI since it gives quantitative measure of user performance. This makes it possible to do comparative analyses of different interfaces or computer systems relatively easily (Preece et al, 2002:453). Hochstein (2002) points out that since GOMS can provide quantitative estimates of task execution time, it can be considered a verifiable theory. This characteristic has made it one of the most widely known and used theoretical concepts within the field of HCI and it is considered to be the most mature model for human performance. As stated before, it is useful in predicting the efficiency and effectiveness of a system in situations where it is difficult to do user testing.

GOMs can be used both quantitatively and qualitatively. Since it can be used quantitatively to give a good prediction of performance times and relative learning time, it can be used to make a purchase decision or to compare the training times of two different systems. Qualitatively, GOMS has been used to design training programs and help systems, since the model describes the steps needed to accomplish each of the different tasks (John, 2003:64; John & Kieras, 1996:289).

4.6.1.4 Limitations of GOMS

A main limitation of GOMS is that the predictions it makes are only valid for an expert who does not make errors. This has two shortcomings. Firstly, even expert users make mistakes while using a computer system. Secondly, and related to the first, GOMS does not take into account novice users, who are just learning the system, or intermediate users. Both of these groups are likely to make mistakes. The other limitation of GOMS is that it is highly limited in its scope since it can only model computer-based tasks that involve a small set of highly routine data-entry type tasks. This makes it difficult to predict how a user will carry out his/her tasks in a range of systems, especially extensive or complex systems that are flexible in their use. Finally, GOMS does not take into consideration human factors that are likely to influence performance, such as individual differences, fatigue, mental workload, and social and organisational factors (Preece et al, 2002:454).

Hochstein (2002) identifies other disadvantages of GOMS. It provides no indication of how useful or enjoyable the system will be, because no factor other than execution speed is taken into account. It does not consider current theories of human cognition, which recognise the multi-processing power of human beings. Rather, the GOMS approach assumes that human beings do one task at a time until the series is completed.

Since model-based evaluation techniques such as GOMS make predictions about predictable behaviour, whereas most people are unpredictable, they cannot be used to evaluate how systems will be used in a real-world context (Preece et al, 2002:454). Finally, Cockton, Lavery and Woolrych (2003) suggest that model-based evaluations are still limited and immature in their use, expensive to apply and rarely used in industry.

4.6.2 Model-based evaluation of WBL applications

Just like empirical evaluations, model-based studies are appropriate for identifying usability problems using quantitative data. However, the disadvantages indicated in Section 4.6.1.4

would make model-based evaluation unsuitable for general use in usability evaluations of web-based e-learning applications, since:

- It caters for expert users only and does not take other kinds of users into account. Web-based learning sites should be designed for all the target users, most of whom are not likely to be experts in using the site.
- It is immature in its application and expensive to apply.

4.7 Observational Methods

Observational methods of evaluations are performed by observing the actual users interacting with the system. This may be done by observing the users in their natural setting, or by requiring them to perform a set of predetermined tasks in laboratory-like conditions (Dix et al, 2004:343; Preece et al, 2002:359). Preece (1993:112) states that the observation may be conducted in a place specially selected for the experiment, such as a usability laboratory, or in the workplace environment, but with minimal interference. This method has the advantage of directly identifying the actual user's usability problems.

Think-aloud and protocol analysis are the two main observational techniques used in usability evaluation of computer systems (Dix et al, 2004:343). This chapter describes these two followed by a brief discussion of usability testing, which also involves observing and/or recording of participants. The advantages and limitations of each technique are discussed, and the general issues to consider when using observational techniques, are identified.

4.7.1 Think-aloud and cooperative evaluation

Although evaluators may identify some of the problems users experience with a system just by observing them, this may be insufficient to determine all the problems, since the approach does not give insight into the user's decision processes or attitudes. In the *think- aloud* evaluation technique, the users are not only observed but also asked to elaborate verbally on their actions by describing what they believe is happening, why they chose a particular action, and what they are trying to do (Dix et al, 2004:343).

It is important that the evaluator be supportive of the participant by prompting and listening for clues about the system usability. The evaluator should avoid giving instructions or causing any distraction during the process. After the session, the participant may be invited to comment, make suggestions or answer questions on the session. Since the atmosphere around the think-aloud technique is informal, it normally encourages users to give spontaneous feedback on the system that can lead to the pinpointing of its usability problems (Shneiderman, 1998:131).

A variation of think-aloud is the *cooperative evaluation* technique in which the evaluator not only observes the user, but is free to ask him/her questions. The user likewise does not only think aloud and answer questions but can also ask the evaluator questions when a problem arises. This technique makes the user more of a collaborator than an experimental subject and has the following advantages (Dix et al, 2004:343):

- The process is easier for the evaluator to learn since it is less constrained;
- The user is encouraged to criticise the system; and
- Points that are not clear can immediately be clarified by the evaluator.

One of the main concerns with these techniques is that users may change their behaviour when they are aware of being observed. Another concern is that the process of verbalising will distract users from performing in the way they normally do (Preece, 1993:119). Furthermore, it is easy for the subject to concentrate on the task in hand and forget to think out aloud. In such cases the evaluator can remind the subject to verbalise (Masemola & De Villiers, 2006:191).

Despite criticisms, these techniques have a number of advantages (Dix et al, 2004:343):

- They are simple to use since little expertise is required;
- They can provide useful insight into problems with the system interface;
- They can be applied even during early stages of system development since, a pencil and paper sketch, or a partial implementation of the system can be used;

- They provide a good understanding of the user's mental model and interaction with the system; and
- Present researcher's note: Think-loud can also be used along with formal usability testing in a laboratory, in which case the utterances can be recorded for subsequent analysis, as discussed in Section 4.7.3.

4.7.2 Protocol analysis

Observational methods, like think-aloud, can only be successful if proper recording of occurrences is done. This is because the analysis that takes place after the observation depends largely on this record. This record is called a *protocol*. The different methods of recording user actions include paper and pencil; audio recording; video recording; and computer logging (Dix et al, 2004:344). These are described in the next subsections.

4.7.2.1 Paper and pencil

In this method the evaluator notes down interpretations and special events as they occur during the observation. Though it is primitive, it has the advantage of being inexpensive. Its main weakness is that what is recorded, is dependent on the speed of writing. To improve on this, some researchers use a coding scheme to represent information, a skill that requires experience or previous training. A notebook computer can also be used to record information. This variation of the paper and pencil method has the drawback that one is limited to the evaluator's typing speed, and loses the flexibility of paper for writing styles, quick diagrams and spatial layout (Dix et al, 2004:344).

4.7.2.2 Audio recording

This is a good method of recording verbal information. However, it may be difficult later in the analysis to synchronise the recorded audio with the actual user actions or with other protocols, such as those done using paper and pencil. (Dix et al, 2004:344).

4.7.2.3 Video recording/ Videotaping

With this method, the participant is recorded using a video camera as he/she performs tasks. Because it may be difficult for one camera to record both the details of the screen and the user, two cameras may be used so that one focuses on the screen and the other takes a wider focus including the user's face and hands. In some cases, a computer may be logged to record details of the tasks performed (Dix et al, 2004:344). Shneiderman and Plaisant (2005:147) point out that while many participants may initially be distracted by the presence of a video camera, within minutes they ignore it and focus on the task in hand.

4.7.2.4 Computer logging

Computer logging is done when the system records statistics about usage as events occur, for example, the number of error messages, speed of user performance or patterns of system usage (Shneiderman & Plaisant, 2005:164). Preece (1993:113) adds that computer loggings or software loggings record the dialogue between the user and the system, and usually consist of time-stamped logs of user actions and system responses.

Computer logging or continuous user performance data logging (Shneiderman & Plaisant, 2005:165) has the dual advantages of not being expensive and of giving useful information about the problems experienced by users when using the system. For example, if the frequency of error messages is recorded, then the area with the highest error count can be pinpointed and fixed. If this was done manually by maintenance staff, it would take much longer and the detection process would be costly to the client. The other advantage, according to Preece (1993:113) and Preece and Moloney-Krichmar (2003:614), is that this method is not as obtrusive as some other observational methods, since there is nobody watching the user during the logging. However, in some cases this method may be used in combination with other methods such as think-aloud and, in such cases, there may be some distraction.

Computer logging is easy to use, but has the problem of qualifying events (for example, the number of errors made) without communicating why they occurred. Another concern is related to technical problems encountered with the analysis of enormous volumes of recorded data. This can be overcome if automatic analysis tools are incorporated within the system (Shneiderman & Plaisant, 2005:165).

4.7.2.5 User notebooks

A variation of computer logging is the user notebook method, where users are asked to keep records, at stated time intervals, of their activities or problems. This approach has the advantage of giving results as interpreted by the user. However, there is a concern that the interpretation may not be accurate, for example, in cases where a user finds it difficult to express his/her thoughts in words (Dix et al, 2004:345).

4.7.2.6 Precautions to take when making protocols

In many cases, the evaluator uses a mixture of protocols to record a session. For example, one may keep paper notes of some of the events, but at the same time use audiovisual recording. When a number of protocols are used, there is considerable difficulty in synchronizing them during playback. The other difficulty is the transcription. It is not easy to type a transcript from a recorded protocol. For example, a tape of a conversation normally consists of broken sentences, mumbled words and external interruptive voices and noises, such as telephones ringing and equipment noises. In addition to this, professional typists may be required for video transcriptions since speed and special annotations are needed. This takes a lot of time and may result in an analyst having tens or hundreds of hours of video recording with only a small fraction of it analysed in detail (Dix et al, 1998:429).

4.7.3 Usability testing

According to Preece et al (2002:323), usability testing (UT) is concerned with the measuring of the performance of typical users on typical task. There are different forms of UT, such as empirical observations and subjective judgements; however, systematic observation-and-recording of user/s in laboratory is the most common (Dumas, 1989:38).

UTs have the following characteristics (Dumas, 2003:1097):

- They focus on usability;
- Participants are end users or potential end users;
- There is an artefact to evaluate such as a prototype, a design or an operational system;
- The participants think aloud as they do the required tasks; and
- Data is recorded and analysed for results.

Certain practical issues must be taken into consideration if the evaluator is to collect and make sense of the stream of data on video, audiotapes, or notes made while observing users during UT. They include (Preece et al, 2002:365):

- The location where the testing is to be performed;
- The equipment to be used; and
- Consent from participants.

These are discussed next.

Location

The location where the testing will take place is important in determining what type of equipment can be installed and used. For example, for recordings done in usability laboratories, several cameras are usually installed. One may record the facial expressions, with another focusing on the mouse and keyboard activities, and yet another recording a broad view of the participant and capturing the body language. The information from these cameras is then fed into a video editing and analysis suite, where it is annotated and partially edited. This type of recording may not be easy to do if the recording is done outside the laboratory, for example, in the user's work environment.

Equipment to be used

All the technology needs to be tested before the session is carried out in order to make sure that it works as expected. For example, the lighting should be appropriate for the cameras.

Consent from participants

Participants should read and sign informed consent before any recording is done. Users should be told about the goal of the study, how long it will take, and what their rights are. If questions are to be asked, the participants should have an idea of the type of question involved. As stated in Section 4.4.6, informed consent is a requirement for all usability evaluation, but it is particularly important for UT with its close-up involvement and subsequent analysis reviewing participants' actions.

4.7.4 Observational evaluation techniques for web-based learning applications

It has been stated in this section, 4.7, that observational techniques have the advantage of directly identifying the user's actual usability problems. However, for web-based learning environments and in the context of this study, they have the following shortcomings:

- Most of them require expensive equipment, such as video or audio recording equipment as discussed in Section 4.7.2.3;
- Large volumes of recorded data may take a long time to transcribe as stated in Section 4.7.2.4; and
- Users (learners) may change their behaviour when they are aware that they are being observed as mentioned in Section 4.7.1.

4.8 Query Techniques

Query techniques are based on the philosophy that the best way to identify usability problems of a system is to ask the user directly. In addition to directly obtaining the user's view point, these methods have the advantage of being relatively simple and cheap to administer (Dix et al, 2004:348; Ardito et al, 2004:190). Interviews and questionnaires, the two main query techniques, are well established techniques in social science, market research and HCI research. They are effective methods of determining what users like or dislike, by asking them directly (Preece et al, 2002:389).

The two main query evaluation techniques – interviews and questionnaires – are discussed in the next two sections.

4.8.1 Interviews

Interviews are methods of gathering information directly from individual users, by verbally querying them about the usability of the system. They can be very productive since the interviewer can pursue specific issues of concern that may lead to focussed and constructive suggestions (Shneiderman & Plaisant, 2005:164). Dix et al (2004:348) believe that the main advantage of interviews is that the level of questioning can be varied to suit the context and that the evaluator can probe the user more deeply on specific issues as they arise. This can be done by using a top-down approach where the interviewer starts with a general question and progresses to specific questions about a task.

Interviews should be planned in advance by defining a set of core questions to be asked. This does not only assist in ensuring consistency between interviews conducted with different users, but also helps to focus on the purpose of the interview (Dix et al, 2004:348). When planning and developing questions for interviews, the following guidelines should be followed (Preece et al, 2002:390):

- Avoid long questions, since the participant will not remember every aspect of such questions;
- Break down compound questions into short simple questions, which are easier to answer;
- Avoid the use of jargon and language that the participant may not understand, but would be too embarrassed to admit;
- Avoid leading questions, for the participants may be afraid of giving an answer that is opposite to what the questions suggest; and
- Be aware of personal biases, so that they are not conveyed during questioning.

Interviews function well as a supplementary evaluation approach following after some other UEM. In this situation, they can be used to further investigate issues or stances that emerged in the earlier evaluation/s.

Depending on the evaluation goals, interviews can be unstructured, structured, semi-structured, or group interviews (Preece et al, 2002:390). These types will be discussed in the next four subsections

4.8.1.1 Unstructured interviews

An unstructured or open-ended interview lies at one end of the spectrum of the degree of control exerted by the evaluator during interview session. It is called open-ended because open questions, questions where the interviewee can express his/her own opinion freely, are asked. The direction of the interview is determined by both the interviewee and interviewer, since progress of the interview is not predetermined, though the interviewer must make sure the interview is within the scope of the prescribed goals. Interviews are similar to conversations because they focus on a particular topic and probe it in more detail. It is important to have a plan or agenda to accomplish the goal of the interview if it is to succeed, although this should not be confused with not being open to dealing with new information and ideas as they emerge (Preece et al, 2002:392).

It is important to remember the following points about interviews (Preece et al, 2002:392):

- Make sure there is an interview agenda supporting the study goals and questions;
- Be prepared to follow new lines of enquiry of benefit to the agenda;
- Ethical issues are very important, such as the need to obtain informed consent from the participant;
- Make sure the interviewee is at ease. For example, the interviewer should dress in such a way as to elicit acceptance from him/her;
- Make it clear as to when the interview session starts and when it ends;
- Do not influence, by any bias, the answers provided by the interviewee; and
- Structure the data and analyse it immediately after the interview, before information is forgotten.

The major benefit of the unstructured interview is the richness of the data generated. This is because in the course of the interview, interviewees mention things not anticipated by the interviewer and these can be probed further. However, this comes at a cost since interviews may generate a lot of unstructured data that can be very time-consuming and difficult to analyse. This also makes it difficult to standardise the interview across different interviewees, since each interview takes on its own format (Preece et al, 2002:393).

4.8.1.2 Structured interviews

In this approach of interviewing, the interviewee is asked a set of predetermined questions with no scope for expression of individual attitudes. This type of interviewing tends to be easier to conduct and considerably easier to analyse than an unstructured one (Preece, 1993:115). Preece et al (2002:394) point out that structured interviews should be used when the goals of the study are clearly understood and specific questions can be identified. To achieve this, the questions asked should be short and clearly worded, and the responses would usually be in the form of a set of options read out or presented on paper. In most cases, such questions are closed and therefore require precise answers. This setup makes it possible to standardise the study since the same questions are asked to all participants.

4.8.1.3 Semi-structured interviews

These have features of both structured and unstructured interviews and therefore use both closed and open questions. In order to be consistent with all participants, the interviewer has a basic script for guidance, so that the same areas are covered with each interviewee. Normally the session starts with a set of preplanned questions, and then an opportunity is given to the interviewee to elaborate or provide more relevant information if he/she opts to do so. This approach to interviewing has the advantages of both structured and unstructured interviews (Preece et al, 2002:394).

4.8.1.4 Group interviews

After a series of individual interviews, focus-group discussions or group interviews can be carried out to further explore the general nature of the comments from different individuals (Shneiderman & Plaisant, 2005:164). A representative sample is drawn from the people who were interviewed and the evaluator works as a facilitator by asking simple questions and coordinating the responses from the group. The main benefit of group interviews is that sensitive or diverse issues that could have been missed in individual interviews, are raised. The approach is based on the assumption that individuals develop opinions within a social context by talking to each other. In a group, people develop and express ideas they would not have thought about on their own (Preece et al, 2002:396).

4.8.1.5 Advantages and disadvantages of interviews

The main drawback to interviews, especially the unstructured ones, is that they are expensive and time consuming. However, direct contact with the users often leads to specific, constructive suggestions (Shneiderman & Plaisant, 2005:164). In addition to this, interviews have the following advantages (Genise, 2002):

- They are good at obtaining detailed information;
- Few participants are needed; and
- Present researcher’s note: as stated in Section 4.8.1, interviews serve well when conducted after some other UEM so as to follow up on issues that emerged.

4.8.2 Questionnaires

Questionnaires are one of the most established techniques of collecting demographic data and users’ opinions. They generally consist of closed or open question structures (Preece et al, 2002:398). Open questions are those where the respondent can express his/her own answer freely, whereas closed questions require him/her to select an answer from a choice of options provided. Though open questions provide a rich source of data, the data is more difficult to analyse than that from closed questions (Preece, 1993:115).

Before carrying out a large scale survey, questionnaires should be prepared, reviewed with colleagues and pilot-tested with a small sample of users. The design of how the data will be statistically analysed and presented should also be done, possibly in consultation with statisticians, before the survey is conducted, if the study is to be successful (Shneiderman & Plaisant, 2005:151).

It is important to note that when carrying out surveys using questionnaires, online or paper-based questionnaires can be used. The online ones should be short and brief, because online respondents rarely have the time and patience to complete them. They have the advantage of avoiding cost and the effort of printing, distributing and collecting, which are characteristics of paper-based questionnaires (Shneiderman & Plaisant, 2005:151).

Questionnaires should start with general questions that require the respondent to provide basic demographic information and information about their experience. This information is useful in determining the range within the sample group. After the general questions, specific questions that contribute to the evaluation goal should follow (Preece et al, 2002:399). In general, the following guidelines should be used in designing questionnaires (Preece et al, 2002:400):

- Make the questions clear and specific;
- Try to ask closed questions, where possible, with a range of answers to choose from;
- For questions that seek for opinions, include an option for a neutral opinion;
- Give considerable thought to the way the questions are ordered because the response to questions can be influenced by their order;
- Avoid jargon and consider whether different questionnaires will be needed for different populations;
- Make sure the instructions on how to complete the questionnaire, are clear;
- Because respondents are deterred by long questionnaires, a balance should be made between using large white spaces and the need to keep the questionnaire as compact as possible; and
- If scales are used, make sure their ordering is consistent and intuitive. For example, in a scale of 1 to 5, 1 should indicate low agreement and 5 indicate high agreement, and this should be consistent throughout the questionnaire.

Although, questionnaires are a good query method of collecting information for evaluating a system, they have the disadvantage of being less flexible in comparison to some other methods, such as interviews. This is because questions are predetermined and fixed for all users, and not customised to individuals. However, questionnaires have the advantage of reaching a wider subject group as compared to interviews, and are cheap and easy to use (Dix et al, 2004:348; Shneiderman & Plaisant, 2005:150).

4.8.3 Query techniques for web-based learning applications

Query techniques, such as interviews and questionnaires, are based on the philosophy that the best way to find out the usability problems of a system is to ask the user. Their main advantage is that they are relatively simple and cheap to administer. These characteristics make query techniques attractive for evaluation of web-based learning applications since educators and course designers need efficient and cost-effective methods to evaluate these applications, as has been mentioned in Section 1.1. These techniques are applied in this study as described in chapter 7.

4.9 Expert Evaluation Methods

Expert evaluations or reviews are forms of *inspection methods* in which experts inspect the human-computer interface so as to predict problems users would face when interacting with it. They have been used since the early 1990s as an alternative to evaluation with end users. This followed after the recognition that users are not always easily accessible or that involving them would make the evaluation process too expensive or time consuming. Expert evaluations include techniques such as heuristic evaluation and walkthroughs. Apart from being inexpensive, these techniques are generally easy to learn and are effective in identifying usability problems (Preece et al, 2002:407). Expert evaluations are also referred to as usability inspections or interface-developers methods, for they are based on an evaluator inspecting the usability related features of a user interface (Hix, Swan, Hollerer, Baillot, Gabbard, Livingston, Julier & Brown, 2004:2; Lazar, 2003:725; Mack & Nielsen, 1994:1).

This section describes heuristic evaluation and walkthroughs, the two main expert-based evaluation methods.

4.9.1 Heuristic Evaluation

4.9.1.1 What is heuristic evaluation?

Heuristic evaluation is an informal usability inspection technique, developed by Nielsen and his colleagues in 1990, where experts, guided by a set of *usability principles*, evaluate whether a user interface conforms to these principles (Hix et al, 2004:2; Nielsen, 1992:373; Preece et al, 2002:408). These principles, or criteria, are referred to as *heuristics*. Dix et al (2004:324) defines a heuristic as a guideline or general principle, or rule of thumb, that can guide a design decision or be used to critique a decision that has already been made. Heuristic evaluation is one of the most established and cost-effective technique for usability evaluation of systems (Paddison & Englefield, 2003:126).

Heuristic evaluation involves having a small set of evaluators who examine the interface of the system and judge its compliance with the heuristics. It is generally not possible for a single evaluator to identify all usability problems in a system. However, it has been determined that different evaluators or experts find different usability problems, which may not be mutually exclusive. This means that when more experts are involved with the evaluation of a particular system, more problems are discovered. Despite this, it is recommended that three to five evaluators be used since not much additional information is gained using a larger number (Nielsen, 1994:26-33). Figure 4.3 shows the relationship between the proportion of usability problems found in an interface and the number of evaluators.

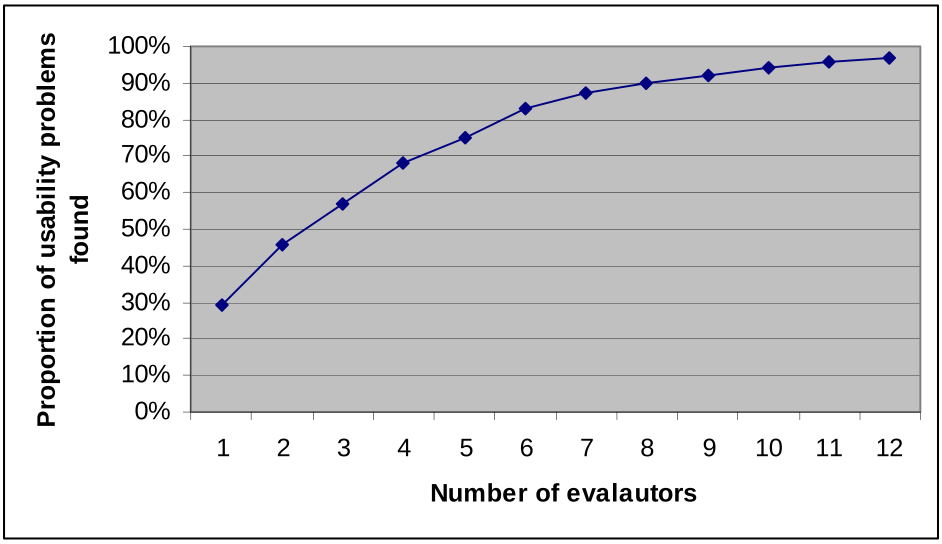

Figure 4.3: ***Proportion of usability problems in an interface found by heuristic evaluation using various numbers of evaluators (Nielsen, 1994:33)***

The curve shows that a single heuristic evaluator discovers about 29% of the usability problems. This percentage increases as more evaluators are used, which means that a larger proportion of usability problems are identified as the number of experts increases. The graph confirms that it is reasonable to recommend the use of five evaluators, certainly at least three, in order to identify 65% to 75% of the usability problems (Nielsen, 1994:26-33).

In addition to the professional HCI evaluators, evaluations can be done by evaluators who are experts in both HCI and also in the domain area, for example, educators for educational interfaces. These are known as 'double experts' and normally two to three of them will point out the same percentage as three to five HCI experts (Karoulis & Pombortsis, 2003:97).

The main aim of HE evaluation is to identify usability problems in a system. This is easier to do on actual operational systems than on paper prototypes (Nielsen, 1992:373). This is confirmed by Peng, Ramaiach and Foo (2004:47) who suggest that HE is more effective in real and deployed systems.

4.9.1.2 Examples of heuristics

Nielsen and Molich first proposed nine usability heuristics for system interfaces in 1990 that can aid an evaluator in identifying usability problems (Molich & Nielsen, 1990:339; Nielsen, 1994:29). They are:

1. Use simple and natural dialogue;
2. Speak the user's language;
3. Minimise user's memory load;.
4. Be consistent;
5. Provide feedback;
6. Provide clearly marked exits;
7. Provide shortcuts;
8. Give good error messages; and
9. Prevent errors.

Elaboration of each of these heuristics are found in the expanded and adapted list of heuristics (Nielsen, 1994:30), which were developed when the nine heuristics were revised to give a set of ten heuristics that have been used widely to determine the usability of different systems (Dix et al, 2004:325; Nielsen, 1994:30; Squires & Preece, 1999:472):

1. **Visibility of the system status**: Users should know where they are within the system. Clearly marked choices of what they can do next should be available through system information and via appropriate feedback, within reasonable time.
2. **Match between the system and the real world**: The metaphors used should correspond to real world objects and concepts. The system should speak the user's language by using terms, phrases, symbols and concepts familiar to the user and common to the natural domain in which the system is applicable, in a logical order.
3. **User control and freedom**: Users should be able to exit the system at any time when they need to do so. Even when they have made errors, there should be clearly marked 'emergency exits' to leave the unwanted state without having to go through an extended dialogue.

4. **Consistency and standards**: The system should be consistent in that the same words, situations, or actions refer to the same thing. It is advisable to use standard platform conventions.
5. **Error prevention**: Apart from giving good error messages, the system should be designed to prevent errors from occurring.
6. **Recognition rather than recall**: Objects, actions and options should be visible, so that the user does not need to recall information from one part of the interaction to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
7. **Flexibility and efficiency of use**: The system should cater for the efficiency of the users, whether they are novices or experts. For example, shortcuts, unseen by the novice users, may be provided to speed up the interaction for expert users.
8. **Aesthetic and minimalist design**: system dialogue should contain only the information relevant to the task to be performed by the system. Irrelevant information may diminish the visibility of the relevant aspects.
9. **Help users recognise, diagnose, and recover from errors**: the system should give error messages expressed in plain language. The messages should indicate precisely what the problem is and suggest constructive solutions.
10. **Help and documentation:** every system should be accompanied by help and other documentation. The information provided should be easy to search, be focused on the user's task, and should list concrete steps to be carried out by the user of the system.

Complementary to the given heuristics, Shneiderman and Plaisant (2005:74) suggest that system usability should be evaluated against the following eight 'golden' guidelines:

1. **Strive for consistency**: There should be consistency in the sequences of actions taken in similar situations, as well as consistency in the deployment of user interface artefacts or objects such as prompts, screens, menus, colours, fonts and layout used throughout the system.
2. **Enable frequent users to use shortcuts**: When users become more experienced, they desire to reduce the number of interactions and wish to increase the speed of accomplishing tasks.

The system should have options, such as abbreviations, special keys, hidden commands and macros that frequent users should use.

3. **Offer information feedback**: For every action taken by the user, there should be a system feedback in order for the user to understand the result of that action. If this is not done, the user may not know whether the action has accomplished the intention successfully or not. For example, if a user uses shortcut keys to save a document in a Windows environment, and if there is no visible or audio response from the system, the user will not know whether the document has been saved or not.
4. **Design dialogues to yield closure:** Sequences of actions should be organised into beginning, middle and end groups so that the user knows where he/she is at any given time.
5. **Offer error prevention and simple error handling**: Though it may be impossible to design a system in which users cannot make any error, the system should be designed so that they cannot make serious errors. If an error is made, the system should detect it and offer simple, constructive, and specific instructions for recovery. For example, menu or icon-driven interfaces should be employed instead of a command-driven one, and if a typed command results in an error, the user should not have to retype the entire command, but rather repair the faulty part.
6. **Permit easy reversal of actions**: actions performed by users should be reversible where possible. The system should provide both 'undo' and 'redo' in order to reduce the anxiety of the user, since he/she would be able to revert to the previous state, the state in which the system was in before his/her action. This gives the user confidence in using and exploring the system.
7. **Support internal locus of control**: Users should be in control of the system and the system should respond to actions initiated by the user. A system with, for example, surprising actions or a tedious sequence of data entries, will build anxiety, frustration and dissatisfaction.
8. **Minimisation of short-term memory load**: Due to the limitation of human-information processing in short-term memory, displays should be kept simple and multiple page displays minimised, so that the user does not have to memorise what he/she did before in order to perform the next task.

The existence of the ten heuristics and the eight golden rules, not mutually exclusive, shows that there are some *general* principles, or heuristics, that are used in usability evaluation of any computer interface. It is intended that such heuristics be used in this study to contribute to usability evaluation of a web-based learning site.

4.9.1.3 Domain-specific heuristics

Heuristics are normally derived from academic and professional research studies, existing criteria lists, or field observations and prior experience in the given domain (Karoulis & Pombortsis, 2003:97). The general heuristics, such as those in the last section, are a result of general rules for user interfaces. In addition to these heuristics that should be considered for all general dialogues, the evaluator can add other usability heuristics pertaining to the specific domain in which the system is used (Nielsen, 1994:28). Some of the generic, or core heuristics are too general, so there is a need to develop heuristics for new products or specific applications (Preece et al, 2002:409). These could be completely new or a modification of the general ones. For example, Barber (2002) proposes four extra heuristics in addition to the ten general ones by Nielsen to make a set of fourteen *website heuristics.* The extra four are:

1. **Navigation:** The system should provide navigational feedback so that the user knows where he/she has been, where he/she is, and the link options he/she has on where to go next. Navigational aids such as search facilities should be available.
2. **Structure of information:** Information should be organised in a hierarchical manner, from general to specific, with related information clustered together with clearly labelled headings and titles. The size of each page should be suitable for the display device size in order to minimise scrolling and to make it easy to scan content.
3. **Physical constraints:** Distances between the target objects, such as icons, and the sizes of the objects should be appropriate so that each target can be easy to reach and manipulate.
4. **Extraordinary users:** The site should cater for people with disabilities, for example, the colour blind, older users, the blind, and dumb. Particular needs, such as the social and cultural needs of the target group, whether local, national or international, should be considered and addressed.

Heuristics can be developed for different products such as toys, mobile telephones, online communities and wearable computing devices by tailoring core heuristics, such as those of Nielsen, and by referring to design guidelines, market research and requirements documents. The nature and number of heuristics required are still debatable, but should not be too many in number (Preece et al, 2002:409).

4.9.1.4 How to perform a heuristic evaluation

Before performing an evaluation, the evaluators or experts should be selected. It is important that caution and thought be given to the selection of evaluators by taking the following into account (Preece, 1993:111):

- To ensure impartiality, the expert should not have been involved with any previous version of the system or in the development of its prototype;
- He/she should have suitable experience in evaluating systems;
- The expert should be briefed so that he/she has a clear understanding of the system usage; and
- The tasks to be performed and material, such as manuals and tutorials to be used by the expert, should be representative of those of the end users.

An evaluation session should last one to two hours. Systems with complicated interfaces with a substantial number of dialogue elements may require more time, but in such cases the process should be divided into smaller sessions, each concentrating on a given part of the system. During the evaluation session, each evaluator, on his/her own, goes through the interface, analysing the various dialogue elements and comparing them with the set of heuristics or criteria. Though the evaluators can personally decide on how to proceed with the evaluation process, it is recommended that they go thorough the system twice. The first pass enables the evaluator to get the feel of the interaction flow and the general scope of the system. The actual evaluation is done during the second pass (Nielsen, 1994:28).

The result of any heuristic evaluation is a list of usability problems in the system, with reference to the set of heuristics used (Nielsen, 1994:31). In a slightly different vein, Dix et al (1998:414) state that the purpose of such evaluation is to uncover usability problems, and that whatever issue the evaluator considers to be a potential problem, is indeed a usability problem, and should be noted down without defining exactly to which heuristic it relates.

4.9.1.5 Severity rating

In its original form HE was focused on finding usability problems but was later extended to include a severity rating of the problems (Hartson et al, 2003:160; Nielsen & Phillips, 1993:216). Severity rating is an assessment of the degree to which each problem is perceived to be a potential negative issue for users, usually estimated by using a 3- or 5-point Likert scale (Lindgaard, 2004). Table 4.6 shows an example of a 5-point scale and Table 4.7 shows an example of a 3-point scale.

0	I do not agree that this is a usability problem at all
1	Cosmetic problem only – need not be fixed unless extra time is available on project
2	Minor usability problem – fixing this should be given a low priority
3	Major usability problem – important to fix, so should be given a high priority
4	Usability catastrophe – imperative to fix this before product can be released

Table 4.6: Five-point rating scale for severity of usability problems (Nielsen, 1994:49)

1	Low – Cosmetic or minor, causes minimal difficulty
2	Moderate – causes some problems in doing work or causes the user to stumble, but recovery is possible
3	High – effectively prevents the user from doing work; the user will fail or have extreme difficulty

Table 4.7: Three-point rating scale for severity of usability problems (Pierotti, 1996)

The results of the severity rating process determine whether more usability testing needs to be done. The relative severity of individual usability problems can also be used to prioritise the allocation of resources depending on the seriousness of the each problem (Nielsen, 1994:47).

While it is possible for expert evaluators to rate the severity of each problem during the HE process, a number of researchers (Albion, 1999; Levi & Conrad, 1996:55; Lindgaard, 2004; Nielsen, 1994:48) suggest that rating should be done at a later stage when problems from all the evaluators have been aggregated. This is because it is difficult for the evaluator to make a proper estimation of the severity of the problem during the evaluation when the focus is on finding new usability problems. It is important that severity rating by the evaluators is done independently of each other (Nielsen, 1994:48). Once all the evaluators have rated the consolidated set of problems, an average of the scores is taken to determine whether a particular problem is cosmetic, minor, major or catastrophic.

4.9.1.6 Advantages of heuristic evaluation

Heuristic evaluation is an informal evaluation method that is relatively effective, inexpensive, and easy to perform. It can result in major improvements to a particular user interface (Belkhiter et al, 2003:178-185; Karoulis & Pombortsis, 2003:93). This is the main reason why the heuristic evaluation method is used in this study. It has a number of other advantages, such as (Preece, 1993:111):

- During a short session, a small number of experts can identify a range of usability problems.
- Because of their experience with many system interfaces, it is easy for evaluators to suggest solutions to the usability problems. The users of the system cannot suggest solutions to some of the problems because they do not have sufficient experience.

Although the main benefit of heuristic evaluation is the identification of usability problems, a further benefit is that the evaluators become more proficient in their personal understanding of usability by comparing their own evaluation reports with those of other evaluators (Nielsen, 1994:34). Apart from identification of problems and suggestions of solutions, heuristic evaluations have the further benefit that they are less costly than methods that involve user testing (Preece, 1993:112). For example, in a study done by Nielsen and Phillips HE was found to be 4.9 times cheaper than user testing (Nielsen & Phillips, 1993:214). One of the reasons for its cost-effectiveness is that it does not use sophisticated equipment or expensive field experiments or broad-scale interviews with high processing overheads (Ardito et al, 2006:274).

4.9.1.7 Shortcomings of the heuristic evaluation method

Some of the major drawbacks of heuristic evaluation are (Preece, 1993:112):

- Sometimes experts are biased, due to their strong subjective views and preferences, and this may lead to biased reports;
- It is not easy to find people who are experienced in both the specific domain of the system and HCI research, i.e. ‘double experts’ are not readily available;
- If proper role playing is to be done, the evaluator needs an extraordinary amount of information about the knowledge level of the users, their typical tasks and their responses to problems; and
- It is debatable whether expert evaluation can capture the variety of real users’ behaviours. For example, novice users may perform unexpected actions that an evaluator might not think of.

4.9.2 Walkthroughs

Walkthroughs, like heuristic evaluation, are methods of predicting users’ problems without doing user testing. They are carried out by experts ‘walking through’ the tasks and recording the problematic usability features. Most walkthroughs – such as cognitive walkthroughs – do not involve users, though some of them, such as pluralist walkthroughs involve a team made up of users, developers and usability experts (Preece et al, 2002:420). This study will discuss cognitive and pluralist walkthroughs.

4.9.2.1 Cognitive walkthrough

A cognitive walkthrough is a combination of software walkthroughs normally used to detect ‘bugs’ in computer program codes and a cognitive model of learning by exploration (Jeffries, Miller, Wharton & Uyeda, 1991:119). It involves a detailed review of the sequence of actions or steps that an interface requires users to perform in order to accomplish some task. The evaluator goes through these steps to determine potential usability problems in the system. The main focus of a cognitive walkthrough is to determine how easy it is to learn to use the system. Since many users prefer to learn how to use a system by exploring its functionality hands-on, instead of by training or by using learner manuals, systems should be designed so that they are easy to learn through exploration. With this in mind, the evaluator goes through each step in the task and provides a rationale about why each of the steps is, or is not, good for the user (Dix et al, 2004:321). In support of these views, Wharton, Rieman, Lewis and Polson (1994:108) add that a cognitive walkthrough involves one or more evaluators who inspect an interface by going through a set of tasks and evaluating their understandability and ease of learning. The user interface is usually presented in the form of a paper mock-up or working prototype, but can also be a fully developed interface. Though this method is best used in the design stage of the system, it may be used during implementation and deployment of the system.

Four items should be in place for the evaluator to conduct a cognitive walkthrough (Blandford et al, 2004:30; Dix et al, 2004:321; Wharton et al, 1994:109-111):

1. **A description of the prototype of the system**: This may be fairly detailed so that the evaluator can visualise the system. The definition of the interface should describe the prompts for every action and the reaction of the interface to such actions.
2. **A description of the task to be performed on the system**: Such a task should be representative of what most users will want to do. The selection of the tasks should be based on the results of studies such as marketing studies, needs analysis and requirements analysis.
3. **A complete written list of actions that are needed to complete the task**: For each task there should be a description of the sequence of actions that should be taken to accomplish that task in accordance with the current definition of the interface.
4. **An indication of who the potential users are and what kind of experience and knowledge they have**: This should include the specific background experience and technical knowledge that could influence the users as they attempt to deal with a new interface. Information should be provided about the users' knowledge of the task and the interface.

Once the evaluator has this information, he/she will walk through the action sequence to critique the system so that a 'believable story' can be told about the usability of the system (Dix et al, 2004:321). To do this, for each action, the evaluators try to answer the following questions (Dix et al, 2004:321; Wharton et al, 1994:112):

- **Will the users be trying to produce the effect that the action actually has?** One needs to know whether the assumptions about the task the action is supporting are correct, in view of the users' experience and knowledge up to this point in the interaction.
- **Will the users be able to identify the correct action?** This questions seeks to find out whether the required option, such as menu or button, is easily visible, and whether the user will be able to use it appropriately.
- **Once the users find the action at the interface, will they know that it is the right one for the effect they are trying to produce?**
- **After the action is taken, will users understand the feedback they get?** To complete the evaluation cycle, users need appropriate feedback about the consequences of their actions. This applies for both correct and incorrect actions.

Once a walkthrough has been done, a usability problem report should be produced indicating what is good in the system and what needs to be improved, as well as the severity of such problems. Such a report will be used by the system designer not only to rectify the problems, but also to prioritise them (Dix et al, 2004:321).

The main advantage of cognitive evaluation is that it focuses on users' problems in detail without involving users themselves. Another advantage is that it is not necessary to have a working prototype to perform the evaluation. However, this evaluation method is very time-consuming and not easy to perform (Preece et al, 2002:421).

Another version of cognitive walkthrough is the pluralistic walkthrough (Preece et al, 2002:423) which is discussed in the next section.

4.9.2.2 Pluralistic walkthrough

In pluralistic walkthroughs, users, developers and usability experts work together to step through a set of tasks to discuss and evaluate the usability issues associated with the system (Mack & Nielsen, 1994:4). All the participants, except the coordinator, assume the role of the user during the walkthrough. The walkthrough is then performed according to the following steps (Bias, 1994:65; Preece et al, 2002:423):

- Scenarios, in the form of a series of hard-copy screens, representing a single path through the interface, are developed before the walkthrough.
- The scenarios are presented to each member of the group, and each is asked to write down the actions he/she would take to move from one screen to another. Each individual does this separately, writing down as much detail as they can, down to the keystroke level.
- When all the participants have finished, the panel members discuss the actions they suggested, starting with the users, then the usability experts and finally the developers. This sequence is used so that the users are not influenced by other panel members.
- The coordinator discusses what modifications of the screens should be made and the panel moves on to the next round of screens. This procedure is repeated until all scenarios have been evaluated.

Limitations of pluralistic walkthroughs

Despite the many benefits indicated in the next paragraph, pluralistic walkthroughs have certain limitations, including the following (Bias, 1994:68):

- The walkthrough cannot move faster than the slowest person on the panel, because all team members should have written their responses before the next screen is investigated.
- The walkthrough does not explore all the possible paths, as real users often do, for it uses the path that the moderator of the walkthrough decides to follow.
- If a participant takes a path that is not the same as that required by the moderator, even if this path performs the task correctly, it will be construed as the wrong path and the participant will have to redo the task.

Benefits of pluralistic walkthroughs

Pluralist walkthroughs have a number of benefits that contribute to their usefulness as a valuable tool in usability evaluation. They include the following (Bias, 1994:70):

- Pluralist walkthroughs can be used in the early stages of system development, even if only in the form of paper mock-ups.

- As criticism of the interface is done, participants usually suggest potential solutions.
- Walkthroughs allow all participants to share their understanding of the requirements of the system, which results in a better understanding and application of these requirements.
- There is immediate feedback to the developers by the users about the design of the system.
- There is increased buy-in by the users, since they participate in the development of the system.
- Pluralist walkthroughs are not excessively time consuming (in certain known instances, they have taken about two days to coordinate) and have been found to be cost effective in some cases.

4.9.3 Expert evaluation methods for web-based learning applications

Expert evaluations are usability evaluation methods where experts inspect the human-computer interface in order to predict user problems. These methods are used in cases where users are not easily accessible or where involving them may make the evaluation process too expensive or too time consuming, as discussed at the beginning of this section (Section 4.9). However, the different expert evaluation methods have different implications in terms of evaluating web-based learning applications, as discussed in the next two subsections.

4.9.3.1 Implication of heuristic evaluation for WBL

As stated in Section 1.1 and Section 4.9.1.6, heuristic evaluation is effective, inexpensive, easy and fast to perform, and results in major improvements to a particular user interface. This has made it the most widely used evaluation method for computer system interfaces, and the reason for its use as one of the focus evaluation methods in this study. The fact that it is easy to learn, perform, and cost effective makes this method suitable for use by designers of e-learning applications. This is because the designers are usually instructional technology design experts or educators, who may not have much knowledge of usability evaluation or lack the resources to perform evaluations, as stated in Section 1.1.

4.9.3.2 Implication of walkthrough evaluation for WBL

Most walkthroughs, such as cognitive walkthroughs, do not involve users, although some of them, such as pluralist walkthroughs involve a team of users, developers and usability experts. The main advantage is that cognitive walkthroughs focuses on users' problems in detail without involving the users themselves. This appears to be a suitable approach for evaluating web-based learning sites. But unfortunately the method is very time-consuming and not easy to perform. Pluralist walkthroughs, on the other hand, have the advantage of allowing all participants to share their understanding of the requirements of the system. This results in a better understanding and application of these requirements but they too are time consuming. This too makes them unattractive for WBL evaluations.

4.10 Comparison of Usability Evaluation Methods

For a researcher setting out to evaluate the usability of a given computer system, the most important consideration is how to select the most appropriate usability evaluation method/s to apply (Fitzpatrick, 1999). A number of UEMs and guidelines have been discussed in this chapter. Different methods do not always produce absolutely consistent results. The choice of the method is often determined by factors such as time, money, and the expertise of the evaluator (Parlangeli et al, 1999:40). This study aims to compare the extent to which two particular evaluation methods – expert evaluation and query techniques – can identify usability problems in web-based e-learning applications. In doing this, the issues mentioned in this paragraph and the rest of this chapter must be considered.

In determining the choice of evaluation method, it is important to address firstly, the factors that distinguish the different UEMs (Dix et al, 2004:357), and, secondly, various practical issues to be considered if the use of a particular method or methods is to be successful (Preece et al, 2002:350). Table 4.8 lists sets of these factors, and issues respectively. Elaborations are given in Sections 4.10.1 and 4.10.2. Equally important is the number of different methods to use in a particular case, and the advantages and disadvantages of each method. These are discussed in Sections 4.10.3 and 4.10.4 respectively.

Factors that distinguish the different evaluation methods (Dix et al, 2004:357)	**Practical issues to consider before carrying out an evaluation (Preece et al, 2002:350)**
• Stage at which evaluation is carried out • Style of evaluation • Level of subjectivity or objectivity of the technique • Type of measures provided • Information provided • Immediacy of the response • Level of interference implied • Resources required • The context	• Users • Facilities and equipment • Schedule and budget constraints • Expertise

Table 4.8: Factors that influence the choice of usability evaluation method/s

4.10.1 Factors that distinguish the different methods

Certain factors distinguish the different evaluation techniques and assist in the determination of which technique to use (Dix et al, 2004:357). The factors, identified in Table 4.8, are discussed in the next subsections**.**

4.10.1.1 Stage at which evaluation is carried out

Evaluation should be carried out throughout the development of a system. In general, evaluations done before system implementation tend to involve experts only and are analytical in nature, while those done after implementation usually involve users, although there are exceptions to this. For example, cognitive walkthrough is expert-based and analytical, but can be done after the implementation of the system. It is important to note that evaluations done in the early stages of system development bring the greatest payoff since problems are easier to resolve at this stage than later on during the implementation (Dix et al, 2004:357).

4.10.1.2 Style of evaluation

The choice between laboratory and field studies is determined by the advantages and disadvantages of each method. Laboratory studies allow the evaluator to undertake controlled experimentation and observation, but lack the naturalness of the user environment. Field studies, on the other hand, allow for a natural ethnographic environment, but do not offer control over user activity. In general, both methods can be used before the implementation of the system, but field studies should mainly be used afterwards (Dix et al, 2004:358).

4.10.1.3 Level of subjectivity or objectivity of the technique

Certain evaluation methods, such as cognitive walkthrough, are subjective in that they rely heavily on the interpretations of the evaluator. Such methods, if they are correctly used, can provide information that cannot be obtained using objective methods. However, the possibility of bias should not be overlooked. One of the ways to minimise this is by using more than one evaluator. Objective methods, such as controlled experiments, should be carried out in such a way that they produce repeatable results that do not depend on the evaluator. Ideally both approaches should be used during the evaluation (Dix et al, 2004:358).

4.10.1.4 Type of measures provided

Measurements can be quantitative or qualitative. Quantitative measurements are numeric and easy to analyse statistically. Qualitative ones are non-numeric and are not easy to analyse, but can provide valuable information that cannot be expressed in numbers. In general, subjective techniques provide qualitative measures and objective ones give quantitative ones. However, it is sometimes possible to quantify qualitative information by mapping it into a scale or similar measure (Dix et al, 2004:358).

4.10.1.5 Information provided

The choice of the evaluation method is also determined by the level of information required. Some evaluations aim for low-level information, such as what font size will be most appropriate, and others seek high-level information, such as determining how well the system satisfies its users. Some evaluation methods are more suitable at certain levels. For example, experiments are good for determining low-level information, whereas query methods such as questionnaires, in surveys, and interviews are suitable for high-level information gathering (Dix et al, 2004:359).

4.10.1.6 Immediacy of the response

Some evaluation techniques – such as think-aloud – provide feedback at the time of the interaction, whereas others – such as interviews – rely on the user's recall. Recollections are likely to suffer from bias and may not provide complete information. However, immediate techniques also have disadvantages, such as those suffered by observational techniques, for example, changes in the user's behaviour when he/she is aware that he/she is being observed (Dix et al, 2004:359).

4.10.1.7 Level of interference implied

Most immediate evaluation techniques, except automatic system logging, are intrusive in that they are obvious to the users during the interaction and run the risk of influencing how they behave (Dix et al, 2004:359).

4.10.1.8 Resources required

The resources available will influence the choice of method used to evaluate a system. For example, it is impossible to do a laboratory experiment if a usability laboratory and the required equipment can not be afforded. Resources include equipment, time, money, subjects and experts. Financial limitations may force the evaluator to use one evaluation method instead of two. In such cases, the evaluator must determine which technique will be most effective for the system under consideration. In some cases, results from previous studies may be used instead of conducting new studies. Some methods, such as analytical ones, rely more on evaluator expertise than others. Consequently, if there is a scarcity of expertise it is more practical to use heuristic methods than analytical ones (Dix et al, 2004:360).

4.10.1.9 The context

The context and circumstances in which the evaluation is to be done contributes to determining the method used. Sometimes, it is not be possible to gain access to the intended users, nor is it possible to test the system in its natural environment. In such cases simulations must be used (Dix et al, 2004:360).

4.10.2 Practical issues to consider before carrying out an evaluation

Before starting any evaluation, a number of practical issues should be taken into consideration if the method to be used is to meet the goals of the evaluation process (Preece et al, 2002:350). Some of these, as identified in Table 4.8, are discussed in the next subsections.

4.10.2.1 Users

It is important that appropriate users be selected for an evaluation, particularly in cases such as usability testing in a laboratory study. Depending on the evaluation method, one should make sure that the users involved are representative of the target user population. The level of expertise, whether novice, intermittent or expert users, gender, age range, cultural diversity, educational experience and personality differences are all important aspects to consider. A further aspect to consider is how the users will be involved in the evaluation. Though the tasks selected should be representative of those performed by the real system, there is no mandatory rule on how long the users should spend on a task. However, the tasks should not be too short or too long. It is recommended that subjects using computers should have breaks every twenty minutes in order to move around and relax. Whether they are paid or not, users should be treated courteously if they are to perform tasks normally. They should not be treated condescendingly or made to feel uncomfortable when they make mistakes. In order to put them at ease with the system, users should be greeted and informed that it is not they themselves being tested, but the system. They should also be given an initial activity to familiarise themselves with the system before the evaluation begins (Preece et al, 2002:350).

4.10.2.2 Facilities and equipment

Several practical issues arise when equipment is used in the evaluation. For example, if video recording is to be done, one needs to decide on the number of cameras to use and where to place them. The more cameras used, the more activities are likely to be captured during the recording. The location of the cameras may influence how the users perform certain tasks. For example, some users will not perform normally when under close scrutiny by cameras (Preece et al, 2002:350).

4.10.2.3 Schedule and budget constraints

It is important to have preset time and budget constraints. For example, though it might be ideal to have twenty users testing an interface, the costs, if participants are to be paid, may be too high to justify during cost-benefit analysis. It is also critical that evaluations be scheduled so that they are completed in time, especially in commercial settings. Although it is not easy in practice to abide by time schedules, it is essential both for the sake of other users and for the sake of the slots reserved in the testing venue (Preece et al, 2002:351).

4.10.2.4 Expertise

Before a particular method is used for the evaluation of a system, it should first be established that there is appropriate expertise to carry out the process. For example, one cannot conduct an expert review if no expert is available. Similarly, if statistics are to be used, a statistician should be consulted before starting the evaluation and possibly later when data is analysed (Preece et al, 2002:351).

Apart from operational issues, ethical issues are important when performing evaluations. Participants' privacy and anonymity should be protected by not disclosing personal information and by not associating the data collected with the individuals themselves. Records of personal data such as details about health, employment, education, financial status and contact details should be kept confidential (Preece et al, 2002:351).

Several factors influencing the choice of evaluation methods have been identified. Jeffries et al (1991:124) conclude that the choice of method/s will depend on the goals of the evaluation, the kind of insight required, and the resources available. However, it is important to determine whether one or more evaluation methods are necessary. This is discussed in the next section.

4.10.3 The number of methods needed

Various factors influencing the choice of evaluation method/s, have been identified. However, in order to increase reliability, usability evaluation ideally requires more than one evaluation technique. For example, when investigating ease of use of a system, both expert walkthrough and protocol analysis could be used (Macaulay, 1995:194). Similarly, Lindgaard (2004) points out that while inspection methods and user testing methods – such as heuristic evaluation, walkthroughs, model-based evaluations and experiments – uncover many usability problems in a system, useful supplementary data can be obtained directly from users through methods such as interviews, surveys and observations. This combined approach results in a comprehensive usability evaluation, since the use of different evaluation methods provides different perspectives and highlights different problems.

Lindgaard (2004) suggests that inspection methods such as heuristic evaluation and cognitive walkthroughs should be applied first in the evaluation of a system since they are cheap to use and effective. This should be followed by user testing methods, such as experiments to uncover more usability problems. Finally, methods where users identify or experience problems directly, such as observations and query techniques, may be applied. Thus different usability evaluation methods are used to provide supplementary data. This approach where results from one set of data are used to corroborate those from another type of data is known as *triangulation* (Brannen, 2004:314). This is the approach used to evaluate the target system of this study, as mentioned in Section 1.6.1.

4.10.4 Advantages and disadvantages of various usability evaluation methods

Table 4.8 identified factors that influence the choice of UEM or UEMs, and a brief discussion of each of these followed. This background can be used to compare the different methods described in Sections 4.5 to 4.9 of this chapter. Table 4.9 summarises the major advantages and disadvantages of each method, referring to issues that have already been addressed in Sections 4.5 to 4.9. Table 4.9 indicates that expert evaluations have an overall advantage over other methods. However, as has been discussed in Section 4.10.3, in order to achieve a comprehensive usability evaluation, a number of different methods should be applied in evaluating a system.

4.11 Conclusion

Usability is a measure of the ease with which a system can be learned or used, its safety, effectiveness and efficiency, and the attitude of users towards it. Usability is a key issue in HCI since it is the accepted indicator for the level of quality of a system's user interface. In order to properly discuss usability, it is important to understand HCI issues such as models of interaction, the interaction styles between the computer and the human, and the ergonomics issues in such interactions. The main components of usability are usability design, principles and evaluation. These have been discussed in this chapter.

The usability of any product, such as a web-based e-learning application, must be carefully considered in order to meet the user's needs. The role of evaluation is to ensure that there is an understanding of those needs during the development and use of the product. Evaluation is the process of systematically collecting data that represents the experience of a particular user or group or other stakeholders (e.g. experts) in using a product for a particular task in a given environment. A usability evaluation method or technique is a systematic procedure for recording data relating to interaction with a software product or system.

In this chapter the main usability evaluation methods were identified as: model-based evaluations, expert evaluation methods, observational methods, query techniques and experiments. Each of these has been discussed in detail. The first two are more suitable for evaluations carried out prior to the implementation of the system, before an operational system exists, and the rest are more appropriate at a later stage, though some of the methods can be used at any phase of system development.

In determining which evaluation method to use, it is important to consider the factors distinguishing the different evaluation methods, such as the stage of the cycle at which evaluation is carried out and the practicability of the method – such as the availability and affordability of expertise to carry out the process. These issues determine the extent to which a method can successfully be used. The advantages and disadvantages of the method/s will also influence the choice. Though expert evaluation methods seem to have more advantages than others, in general, a comprehensive usability evaluation requires the use of more than one evaluation technique, i.e. a hybrid approach, since different methods produce findings relating to different aspects.

This chapter has pointed out that, in addition to user satisfaction, usability – from the HCI perspective – concentrates on the effectiveness and efficiency of the interaction between the system interface and the user in performing a task in a particular environment. However, Dillon and Zhu (1997:223) note that, in the case of educational applications, the effective and efficient performance of tasks may not necessarily result in learning. With the background of learning theories and e-learning models from Chapters 2 and 3, and system usability, as discussed in this chapter, in the next chapter criteria are derived that aim to integrate usability and learning.

Method	**Advantages**	**Disadvantages**
Empirical Evaluations (Experiments)	Powerful established method. Produces quantitative data for statistical analysis. Good reliability and validity of results can be replicated.	Demands high resources. Requires knowledge of how it is used. Time consuming. Tasks can be artificial and restricted. Results may not be generalised to a full working system in a natural working environment.
Model-Based Evaluation Methods	Useful in early design. Few resources required and therefore inexpensive.	Assumes that all users are experts. Difficult to use since there is limited guidance on how to apply these methods.
Expert Evaluation Methods	Easy to use. Can be used at any stage of system development. Few resources required, and therefore not costly. Have high returns since they detect many problems. Experts can suggest solutions to problem.	Cannot capture real user behaviour. Problems in locating experts. Subject to evaluators bias.
Observational methods and usability testing	Quickly identifies the usability problems. Verbal protocols are valuable source of information.	Observation can affect user activity and performance levels. Analysis of data can be time- and resource-consuming. UT requires expensive technology
Query Techniques	Capture users' opinions. Questions can be tailored to individuals in interviews. Rating scales lead to quantitative results. Questionnaires can be used on large groups.	Low response rate for questionnaires. Possible interviewee and interviewer biases. Analysis of data can be complex and lengthy. Interviews are time consuming.

Table 4.9: Advantages and disadvantages of usability evaluation methods (Preece, 1993:118)

Chapter 5: Usability and Learning: Heuristic Evaluation Criteria

5.1 Introduction

This chapter integrates the concepts discussed in Chapters 2 to 4 (Learning theories, Web-based learning and Usability, respectively) of this study in order to derive criteria appropriate for usability evaluation of web-based e-learning applications, and thus to answer the first research subquestion in Section 1.2.2, of this study, namely:

- *"What criteria are appropriate for usability evaluation of a web-based learning environment for a 3rd year Information Systems course in a tertiary education institution?"*

The aim is to integrate e-learning and usability. These criteria/heuristics form the basis for the heuristic evaluation by experts and the survey and interview evaluations by learners.

As stated in Section 1.1, evaluations of any educational software should investigate both its pedagogical effectiveness and its usability. Furthermore, in identifying criteria for evaluating e-learning applications, the peculiarity of e-learning must be considered, since its primary goal is to support learners in learning the didactic content material in such a way that they devote minimum effort to the actual interaction with the application (Ardito et al, 2004:190) followed by concerted effort in engaging with the learning content. The integration of usability and learning should therefore address usability features that are important to achieve educational goals (Squires & Preece, 1996:15). The evaluation of e-learning applications is further complicated by the increase in diversity of learners, technological advancements and the constantly changing tasks in the real world (Zaharias, 2006:1571).

General interface evaluation criteria, such as Nielsen's heuristics, given in Section 4.9.1.1, can be applied to evaluate e-learning applications. However, problems arise from applying a small set of principles/heuristics to a wide range of systems (Ardito et al, 2006:272). Specific guidelines are needed in order to evaluate usability of e-learning systems. This study can be viewed as a response to that call, as it proposes an integrated set of evaluation criteria which address both usability and educational aspects of e-learning applications.

This chapter starts with an examination of the rationale for, and the debate around, integration of learning and usability. This is done to highlight some of the issues surrounding the process. This is followed by an overview of existing guidelines and heuristics for usability evaluation of general e-learning applications and educational software. Further, heuristics are identified that are appropriate for the evaluation specifically of web-based e-learning applications.

5.2 Rationale for Integration of Usability and Learning

As computers became more powerful and prevalent in the 1980s, educational computing increased and it was realised that the usability of such systems was highly important. Attention was increasingly paid to the role of the end user. Research in the field of human computer interaction began to explore computer usability and the notion of user-centred design (UCD). Now in the 21st century, the HCI community is facing a new challenge of how computers should be used to support individuals or groups of individuals to develop expertise in required skills or in their professions, and in developing deeper and richer understanding of content and practice. A new challenge for HCI is how to support designers who are developing expertise in new and unknown work practices (Quintana, Carra, Krajcik & Soloway, 2002:605). E-learning is one of the areas offering such a challenge, and hence the need arises to integrate usability, from the field of HCI, and learning, emanating from the educational domain.

There is a danger that usability features can be considered at the expense of educational issues. The converse of this is equally true. In some cases there is no consideration of the implication of usability features for educational applications (Jones et al, 1999:499-500). On the other hand, HCI professionals seek to ensure that learners, as users, can interact with technology in a manner that is effective, efficient, and satisfying. While not concerned with learning per se, HCI practitioners seek to include usability features in application systems so as to devise information technology that can be used appropriately by the intended users. However, in the case of educational applications this does not guarantee that learning will occur from using such systems. It will only ensure that willing users can interact with the application in an efficient, effective and satisfying manner (Dillon & Zhu, 1997:223). There are also some arguments that, in general, usability of an educational application in terms of its design does not necessarily result in deep learning. Whether or not this is the case, there is a need to find out how best usability features can be integrated with principled educational design (Mayes & Fowler, 1999:484; Squires, 1999:464). While there are ongoing discussions on the relationship between usability and learning, and acknowledging certain objections to the relevance of usability in instructional software, a study carried out (Tselios et al, 2001:373) shows that there is a positive correlation between usability of the system and performance of the learners in the tasks undertaken.

The main challenge for learners interacting with educational applications, is that they have to deal with two learning processes at the same time: on the one hand, they learn how to interact with the system, and on the other hand, learn how to acquire new skills and expertise. These two are not independent, for they use the same cognitive resources. Therefore, an interface which is difficult to use, could jeopardise the educational success of the system. Whether educational multimedia, in general, do or do not improve learning, studies have indicated convincingly that a difficult-to-use interface negatively affects learning performance (Parlangeli et al, 1999:38). Similarly, a study by Pan, Gay, Saylor, Hembrooke and Henderson (2004:189) concluded that good usability is a necessary condition for learning, for if there is poor usability then the learners waste time attempting to use the system, instead of concentrating on what is to be learned. It was also found that effective learning results in a positive subjective experience.

For most professions, a considerable number of guidelines and heuristics are available. Although much information on usability, information design and graphic arts is available, there is little information on how to create interfaces specific to educational instructional purposes (Lohr, 2000:45). This chapter attempts to suggest criteria that are appropriate for evaluation of web-based e-learning applications, since usability evaluation is an important part of the overall evaluation of any web-based learning environment (Silius & Tervakari, 2003).

5.3 Usability and Learning Evaluation Guidelines

This section discusses guidelines that should be considered in the evaluation of e-learning applications in terms of both their usability and pedagogy. As stated in Section 1.1 and 5.2, these dual aspects should be considered in evaluating any educational software. In line with this study, the section concentrates on *general principles (criteria)* or *heuristics* for evaluation of e-learning applications. Although some new issues that pertain to the *intersection of usability and learning* in the domains of human computer interaction and education, respectively, are introduced, most of them have been discussed in the previous chapters.

The first two subsections discuss general guidelines for integration of usability and learning. The third subsection gives some of the reasons for using heuristics, instead of checklists, for usability evaluation of educational software. This is followed by an overview of a study done by Squires and Preece to determine appropriate heuristics for evaluation of educational software. This overview also serves as an example of how heuristics for learning are derived. The last subsection provides further heuristics from various other studies.

5.3.1 Human computer interaction and instructional design

The field of HCI comprises the study of the interaction between humans and computers with the general aim of informing the designer regarding technology that is acceptable to human end user. Since the field is multidisciplinary, as discussed in Section 4.1, there is no single theory that guides HCI studies. From the HCI perspective, a number of issues emerge in the design of educational applications. These include:

- The tool;
- The learner;
- The task ; and
- The environment.

In particular, focus must be on the learners and their tasks. HCI professionals seek to ensure that learners, as users, can interact with the technology in a manner that is effective, efficient, and satisfying – the three main aspects of usability identified in Section 4.3.1. While not concerned with learning per se, HCI practitioners seek to devise information technology that can be used appropriately by the intended users. In terms of multimedia instruction, this would mean including features such as screen readability, adequate support for navigation and task-relevant commands. This would go some way towards ensuring that, in terms of basic human factors, the minimum usability requirements are met. However, as mentioned in Section 5.2, this in itself is insufficient to guarantee that learning will occur from using the system. It can only ensure that willing users will experience a high level of usability in their interaction with the application. Beyond this, HCI turns to instructional design for principles regarding how to take usable technology and apply instructional theory to its pedagogic use (Dillon & Zhu, 1997:222-3).

Learning cannot be approached as a conventional task that entails certain problems to be solved and various outputs to be produced. Learning, by contrast, is a by-product of something else. Learning and instructional systems are not conventional data processing systems. Educational software requires the design of effective tasks, rather than interfaces. The design must be consistent with the tasks at hand (Squires, 1999:465). The design of instructional materials should take into account the following teaching and learning approaches, if it is to be effective (Squires & Preece, 1999:471):

- Constructive approaches;
- Co-operative learning groups;
- Collaboration with other learners via a network or the Internet;
- Strategies to encourage multiple intelligences and a variety of learning styles and independent investigation;
- Open-ended questioning; and
- Strategies to stimulate learners' creativity.

These issues have already been discussed in Chapters 2 and 3, especially with regard to their relationship to current learning theories and certain e-learning models. The next section addresses the challenges faced in integrating usability with the constructivist learning theory, which is the current dominant intellectual trend in the design of e-learning (Vat, 2001:326).

5.3.2 Usability and constructivism

Constructivist approaches, as discussed in Chapter 2, have been extended to include social perspectives such as situated learning. This implies that the impact of using ICT in learning will depend on the context, with all the components of the learning environment, such as people and artefacts, interacting and contributing to the learning process. It is argued that learning is best supported when technology augments learning rather than attempting to supplant it, and that collaborative learning in which peer group discussion and work is done, is effective in helping students to learn (Squires, 1999:464).

The combination of the principles of constructivism and situated learning is referred to as socio-constructivism. The socio-constructivist view of learning poses challenges for conventional views of usability. Conventionally, usability is conceived in terms of interface design that facilitates efficient and effective completion of well-defined relatively limited tasks. However, socio-constructivism implies that learning environments should be context-sensitive complex environments in which users are expected to make and rectify mistakes as part of the learning process. The need for context-sensitivity is also emphasised in HCI principles for the context-sensitive design and evaluation of software. However there is a mismatch, in dealing with context-sensitivity, between the HCI and the constructivist approach to learning. As already stated, in Section 5.2, usability of an educational application in terms of its design may not necessarily lead to deep learning. There is a need to find out how usability features can be integrated with principled educational design (Squires, 1999:464, Mayes & Fowler, 1999:484). Along similar lines, Squires and Preece (1999:476) distinguish between peripheral usability errors and cognitive errors. Systems should be designed to prevent the former, but to permit the latter while promoting strategies by which learners can recognise them and recover from them.

5.3.3 Why use heuristics for usability evaluation of e-learning applications?

As discussed in Section 4.9.1, heuristics are general principles that can be used to guide a design decision or critique decisions that have already been made. It is easier for educators and instructional designers to evaluate systems by using heuristic criteria than by using lengthy specific checklists, since the former take less time (Brinck & Wood, 2002:410). Moreover, the use of checklists has been questioned by a number of researchers (Squires & Preece, 1996:15). For example, Rohn, Spool, Ektare, Koyani, Muller and Redish (2002:895) used over 400 guidelines in a checklist-based usability evaluation study. However, as an example, in the context of website design, the heuristic 'Be consistent' can be used as a substitute for all the following specific principles (Brinck & Wood, 2002:410):

- Page layouts are consistent throughout the website;
- Page titles are consistent with page names;
- All headers have consistent syntax, capitalisation, and punctuation;
- All bullets are of the same style;
- All logos conform to the same corporate standard;
- Link colour do not vary from page to page; and
- Links colours are consistent with Web conventions: blue for none visited and green or purple for visited ones.

This could reduce the guidelines in the checklists to a few heuristics.

Furthermore, Squires and Preece (1999:471) caution against the use of checklists in the evaluation of educational software due to the following factors:

- It is difficult to indicate relative weightings for questions;
- Checklists focus on technical aspects rather than educational issues;
- Different subjects require different sets of selection criteria; and
- Checklists are tedious to use.

One of the main aims of this study is to establish a set of guidelines that can be used in evaluating WBL applications. The next section is a discussion on some of the major studies that have been undertaken towards the fulfilment of this aim. The discussion takes into account both usability and learning.

5.3.4 Heuristics for learning with software

According to Squires and Preece (1999:473), there is a relationship between the usability heuristics, such as those by Nielsen, Section 4.9.1.2, and the constructivist view of learning, Section 2.2.

The notions of cognitive and contextual authenticity in social-constructivism are used as a basis for relating Nielsen's usability heuristics to socio-constructivist criteria for learning. *Cognitive authenticity*, according to constructivists, refers to learning experiences in which learners are helped to construct and refine concepts in personally meaningful ways (Squires & Preece, 1999:469). The three most important concepts that support cognitive authenticity are: *credibility*, *complexity* and *ownership*. Learners will consider a system to be credible if they can explore the behaviours of the system and get meaningful feedback from it. Learners also need help in order to be able to cope with complexities. Learners should be given a sense of ownership of their learning, by allowing them to take responsibility for their individual learning. *Contextual authenticity* refers to the notion that learning takes place according to the context in which the learning process is situated. The components of the learning environment such as people, including educators and peers, and the artefacts within the environment will all affect the learning process (Squires & Preece, 1999:470). *Collaborative* learning and the *curriculum* itself are the most important aspects of contextualised learning. In collaborative learning students learn by peer-group discussion and work. Curriculum refers to the content to be covered by the students.

Table 5.1 shows some of the possible relationships between Nielsen's heuristics, first column, and the social-constructivist learning criteria, second row. The table shows an interaction between at least one of the heuristics and each of the concepts of *credibility*, *complexity* and *ownership*, which suggests that there is a relationship between *cognitive authenticity* and usability. There is also some interaction between some of heuristics and the concepts of *collaboration* and *curriculum*, which implies a relationship between *contextual authenticity* and usability. The relationships are, in general, based on the learning theory discussed in Chapter 2, and usability of software applications, as discussed in Chapter 4, thus integrating the two major domains of usability and learning.

Nielsen's heuristics	**Cognitive authenticity**			**Contextual authenticity**	
	Credibility	***Complexity***	***Ownership***	***Collaboration***	***Curriculum***
System status visibility	Feedback and designer/learner models	Navigation			
Match system/world	Cosmetic authenticity	Representation of the real world			
User control			Learner control	Shared responsibility	
Consistency		Symbolic representation		Consistent protocols	Subject content
Error prevention		Peripheral cognitive errors			
Recognition	Representational forms				
Flexibility	Multiple views/ representations		Tailoring the interface		Teacher customisation
Aesthetic design		Superficial complexity			
Error recovery	Interaction flow	Pedagogical techniques	Meta-cognition		
Help/ documentation		Learners' support material			

Table 5.1: The relationship between usability and learning evaluation heuristics (Squires & Preece, 1999:474)

Squires and Preece (1999:473-479), expand on the relationships in Table 5.1 between credibility, complexity, ownership, collaboration and curriculum on one hand, and Nielsen's usability heuristics on the other:

- **Credibility –** Its strong relationship with Nielsen's heuristics, includes:
  - **Feedback and designer/learner models**: Tasks should be presented to the learners, according to the designer's mental models and the system should provide specifically designed interactive feedback. This is consistent with constructivism, which emphasises active engagement and feedback on performance.
  - **Cosmetic authenticity**: Avoid over-use of elaborate multimedia, which may result in superficial and possibly misleading matching between images and the real world.
  - **Representational form**: Interaction with the software should not detract from the learning experience. The interface should not require high cognition from the learners. Symbols, icons and names used should be intuitive within the context of the task.
  - **Multiple view/representations**: Educational software should be flexible and use a variety of representations so as to support constructivist learning. Different forms of media, in combination or separately, may be used to support different perspectives.
  - **Interaction flow**: Users need a smooth flow of interaction. Sometimes, feedback in different forms such as error messages and hints may hinder specific task-based learning. The conflicting demands of interaction flow and feedback must therefore be carefully balanced.
- **Complexity –** The relationship between complexity and the heuristics includes:
  - **Navigation**: Navigation is possible in two senses. First, the past, present and future possibilities for manipulating an application should be clear. Second, learners should be able to represent the tasks they are undertaking.
  - **Representation of the real world**: Interfaces should be analogous to some aspect of the real world. Metaphors should correspond to real world objects or concepts.
  - **Symbolic representation**: Objects, such as symbols and icons, should represent educational concepts in a way that assists learners. Concepts and terminologies should be used consistently. On the Web, learners are likely to experience the problem of lack of consistency, but within the design of a single educational application, the design should be consistent.
  - **Peripheral cognitive errors**: As mentioned in Section 5.3.2, there are two types of errors in educational applications: software usability errors and cognitive errors. The former originate from manipulation of software, and need to be minimised since they limit the

efficient manipulation of the learning aspect of the application. Cognitive errors arise when concepts are developed and refined in an attempt to understand the complexity of a learning environment. From the constructivist approach to learning, cognitive errors should be part of educational applications, since learners need to make and remedy cognitive errors as they learn.

- **Superficial complexity**: This is the use of multimedia, such as sound, graphics and video for complex representation of concepts, without much learning content. This should be discouraged and multimedia should, instead, be used to simplify the understanding of complex educational concepts.
- **Pedagogical techniques:** It is a constructivist tenet that people learn by mistakes and that learners need access to a rich and complex environment where they can express their own ideas and explore different solutions to problems.
- **Learners' support material**: Learners need simple specific problems and tasks to help them focus their attention before they encounter complex learning environments.

- **Ownership –** Ownership of ideas is important for learning and includes the following relationships with the heuristics:
  - **Learner control**: Constructivists stress that learners should direct their own learning. This implies that learners should find their own pathways through learning experiences. The Web enables learners to search for information and to discuss issues with peers and educators globally. Educational software should include high levels of learner control, so that learners attaining a sense of ownership of their learning.
  - **Tailoring the interface**: Learners should be able to tailor the interface to support their individual needs and learning strategies – referred to as customisation.
  - **Metacognition**: Learners should reflect on their own cognition in order to improve their learning. This self-appraisal improves the capacity to learn.
- **Collaboration –** Although collaboration is a new concept in education, it is an important component of the social constructivist approach and has the following relationships with the heuristics:
  - **Shared responsibility**: Peer group learning enables learners to delegate some of the control of the learning experience to other members of the group. In this case, the educator assumes the role of a facilitator of the learning process, rather than its director.

- **Consistent protocols**: learners need to develop rules to guide their working practices if they are to learn by collaboration, since they need to be consistent in the way they share resources across networks.

- **Curriculum –** Its relationship with Nielsen's heuristics, includes:
  - **Subject content**: Educational applications' scope should correspond to the curriculum. This is relatively easy to assess for subject-specific applications but rather difficult with generic applications such as spreadsheets.
  - **Teacher customisation**: Educational applications should be customisable so that educators can adapt them to the specific needs of their learners.

These relationships between Nielsen's heuristics and the notions of cognitive and contextual authenticity, were used to generate the following set of evaluative heuristics, referred to as heuristics for "learning with software" (Squires & Preece, 1999:479-480):

1) **Match between learner and designer models**: Though the designer and learner models need not be identical, there should be no logical differences between them. This ensures consistency between the two and minimises misconceptions by learners. Feedback from the system should provide an understandable representation of the cognitive task at hand.
2) **Navigational fidelity**: This relates to navigational structures, cosmetic authenticity, limited representation of the real world and superficial complexity. Good interface usability is important, but it should not compromise authenticity by providing a simplistic representation of the real world.
3) **Appropriate level of learner control**: Learner control and shared responsibility, tailoring of the interface and consistent protocols can give learners a sense of ownership of their learning within a supportive environment, with their peers or teachers as facilitators.
4) **Prevention of peripheral usability errors**: There is a relationship between complexity and error prevention. Cognitive errors are permissible when they are relevant to major learning issues, but peripheral usability-related errors should be anticipated and avoided.
5) **Understandable and meaningful symbolic representation**: This relates to representational forms and the use of symbols within and across applications. Learners

should not have to learn and remember them. This will be possible if the symbols, icons and names used relate to educational concepts.

6) **Support for personally significant approaches to learning**: This is implemented by multiple representations, learner's support materials and metacognition. It should be clear which learning styles are supported and the aspects that relate to learning styles characteristics should be clearly identified.
7) **Strategies for the cognitive error recognition, diagnosis and recovery cycle**: This cycle relates to issues that arise from pedagogical techniques and learning issues. There should be strategies to promote this cycle.
8) **Match with curriculum**: Relevance to the curriculum should be considered. Educators should be able to customise the application according to learner-specific needs and the required scope.

These heuristics are an effort to integrate usability and learning, particularly in the context of the constructivist approach to learning. They have been applied locally by De Villiers (2004:285) in the evaluation of an interactive e-learning application.

5.3.5 Other heuristics for e-learning applications

Apart from the set of heuristics discussed in the previous section, 5.3.4, there are others proposed by researchers, and HCI and educational practitioners, some of which are discussed in Section 5.3.5.2. However, since this study is particularly about web-based e-learning, certain specific heuristics for Web design are identified first.

5.3.5.1 Website design heuristics

Apart from the heuristics for Web design identified in Section 4.9.1.3, there are various further sets. Similar to those in Section 4.9.1.3, many of them are related to Nielsen's general design heuristics, Section 4.9.1.2. This section will list a few of these sets. Where necessary, explanations will be given where the heuristic or its explanation differs from that given in Section 4.9.1.2 in relation to Nielsen's heuristics.

In their study, Levi and Conrad (1996:58) propose nine heuristics for website evaluation. These were derived from the general-purpose Nielsen heuristics and supplemented by web-specific ones:

1 Speak the user's language.
2 Be consistent.
3 Minimize memory load.
4 Build flexible and efficient systems.
5 Design authentic and minimalist systems.
6 Use chunking: materials should be written so that documents are short and contain exactly one topic. Users should not have to assess multiple documents to complete a single discrete task.
7 Provide progressive levels of detail: organise information in a hierarchical form, starting with general information then specific items.
8 Give navigational feedback.
9 Don't lie to the user: do not refer to non-existent information such as missing links.

Meanwhile IBM recommends the following heuristics for evaluation of websites (Bollaert, 2002):

1 State the purpose upfront;
2 Limit the number of wizard screens;
3 Avoid long screens that require scrolling;
4 Provide alternatives for expert users;
5 Avoid technical jargon;
6 Include a cancel option;
7 Inform users of exit consequences;
8 Keep tasks contained within the wizard;
9 Minimize download time;
10 Provide easily assessable help;

11 Break tasks down logically;
12 Inform users of progress;
13 Indicate required fields;
14 Limit navigational options; and
15 Provide summary.

Without ignoring Nielsen's heuristics, Brinck and Wood (2002:411) suggest ten aspects important for Web design:

1 **Content and scope**: The site should have appropriate content, and its scope should be broad enough to satisfy users' requirements.
2 **Speed**: Download time should not be excessively slow. Text should be used primarily, and graphics only where necessary.
3 **Navigation**: The site map should give an accurate understanding of the scope and organisation of the site.
4 **Appropriateness to task**: Users should know where they are in a task, and be aware that information is carried through from each step to the next.
5 **Visual design**: Information should be uncluttered, with emphasis provided where required.
6 **Compatibility**: The site should cater for a range of users and computers. It should address individual, cultural and linguistic differences, as well as being compatible with different browsers, operating systems, hardware devices and networks.
7 **Simplicity**: Everything should be presented in a simple, straightforward way. For example, language should be simple and the pages must not be numerous. Follow the principle of minimalism – that if anything can be removed, then it should be removed.
8 **Consistency and contrast**: Similar things should be done in a similar manner. There should be internal consistency within each page and between pages, and there should be external consistency with Web design standards and conventions. There should also be consistency between the site and actual documents of the organisation.
9 **Error handling**: A site should not accept entry of inappropriate values and, if such are entered, the user should be assisted to recover quickly and efficiently.
10 **Respect for users**: Users should not be exposed to security or privacy risks, nor should they be angered or frustrated by activities on the site.

5.3.5.2 Heuristics specifically for e-learning applications

There are certain heuristics specifically for evaluation of e-learning applications, especially web-based environments. They are related to the issues discussed in Sections 3.4 to 3.6. This section gives some of them, as well as other general principles relating to both learning and usability.

Squires (1997) proposed the following evaluation criteria, in question format, for educational multimedia:

1 Is the complexity level of the environment appropriate?
2 Is the learner active?
3 Is fantasy used in an appropriate way?
4 How appropriate is the content to the curriculum?
5 How navigable is the software?
6 What sort of learner feedback is provided?
7 What is the level of learner control?
8 Are learners motivated when they use the software?

Albion (1999) suggested 28 heuristics for evaluation of educational applications, within three categories:

1 Interface design heuristics (ten of them);
2 Educational design heuristics (nine); and
3 Content heuristics (nine).

The first set is equivalent to Nielsen's set, Section 4.9.1.2, and will not be repeated here. The 'content' heuristics are mainly for use by educators in evaluating learning content, for example, whether or not the content is relevant to the professional practice of teaching. Such issues are outside the scope of this study. The second set, 'educational design' heuristics, are presented in Table 5.2.

Clear goals and objectives	The application makes it clear to the learners as to what is to be accomplished and gained from its use.
Context meaningful to domain and learner	The activities in the application are situated in practice, and will engage and interest learners.
Activities scaffolded	The application provides support for learner activities. This allows them to work with their existing competency as they encounter meaningful chunks of knowledge.
Elicit learner understanding	Learners can articulate their conceptual understanding as a basis for feedback.
Formative evaluation	Constructive feedback is given to the learners as they perform tasks.
Performance should be ‘criteria-referenced’	There are clear and measurable outcomes that support competency-based evaluation.
Support for transfer and acquisition of ‘self-learning’ skills	The application supports transfer of skills beyond the learning environment and facilitates self-improvement of the learner.
Support for collaborative learning	There is support for learners to interact with each other through discussion and other collaborative activities.

Table 5.2: Educational design heuristics (Albion, 1999)

In order to determine whether a system enhances learning, in particular learning by the constructivist approach, the following supplementary heuristics, referred to as ‘learnability heuristics’, can be used for usability evaluation of e-learning applications (Karoulis & Pombortsis, 2003:99):

- Does the system facilitate active interaction between learners and educators?
- Does it support the development of personal problem-solving strategies by learners?
- Are tools available to support the way the learner learns at this level?
- Does the environment afford experimentation with the acquired knowledge?
- Are there multiple representations and multiple solutions for the learner to explore?
- Does the system provide adequate feedback so that the learners can reconsider their strategies?
- Is it possible for learners to assess their own activities?

Vrasidas (2004:913) proposes the following ‘principles for effective online learning’, that can be rephrased to serve as evaluation heuristics:

- **Learner-centricity**: Tools are provided to allow learners to organise information, contribute content, engage in learning activities, and take control of their learning activities.
- **Engagement and activity**: Learners are involved in activities that motivate them and help them use active learning principles to find solutions to problems.
- **Construction**: Learners construct knowledge and meaning while interacting with peers, tools and content.
- **Situated and contextual learning**: Learning is situated in a real-world context and integrates authentic tasks into learning.
- **Collaboration**: Tools are provided for learners to interact with peers and educators by means of asynchronous and synchronous communication.
- **Reflection:** Learners can reflect on their actions, skills, competencies and knowledge.
- **Prompt feedback:** There are agents within the system to provide feedback to learners.
- **Record-keeping**: Features are presented that enable the educators to monitor learners’ progress.

In a study to determine the usability of WBL learning tools, Storey, Phillips, Maczewski and Wang (2002:95) found that WBL tools were simple to use when they were:

- Well designed, easy to use and learn;
- Simple to navigate with a well-designed layout;
- Compatible with other programs and platforms;
- Transparent in their use, so that they do not hinder or frustrate the learner;
- Used to support the course, but not to replace face-to-face contact; and
- Relevant to the course, and its structure and content.

Finally, it should be noted that usability has been found to result in enhanced performance. A study done using Nielsen’s heuristics to determine the correlation between usability and learnability, and the relevance of usability in instructional software showed a significant correlation between the usability of the system and the performance of the learners in the studied task. The most usable system had a significant positive impact on the performance of the learners who used it. The usability aspects investigated in the study were based on the quality of the educational application, in particular its efficiency in interaction, consistency, support in the event of errors, freedom in navigation and use of concepts familiar to the users. These are important issues in an educational context, since they permit the educational software to become transparent and not to interfere with the learning process (Tselios et al, 2001:373).

If all the guidelines are followed, a Web-based environment can be achieved that is usable and that should promote learning.

5.4 Synthesis of Evaluation Criteria for Web-Based Learning

Various heuristics have been discussed in Section 4.9.1, as well as Sections 5.3.4 and 5.3.5. These and other aspects from Chapters 2 to 4 are combined to propose criteria for usability evaluation of web-based e-learning applications. Table 5.3 shows a comprehensive set of such criteria, synthesised by the present researcher

Section 5.3.4 introduced Squires' and Preece's (1999:479-480) heuristics that take into account both learning and usability. Though this is a comprehensive set of heuristics, the present author finds some of them rather general, so, instead of combining usability and learning in this new synthesis, the author takes an approach similar to that of Albion (1999), and recommended by Zaharias (2006:1575), where the heuristics are categorised. There are three categories, containing twenty criteria in total. They are numbered for easy reference:

A

- **Category 1 – General interface design heuristics:** These are based on Nielsen's heuristics but with some extensions influenced by Squires' and Preece's (1999:479) 'learning with software' heuristics, so as to focus them on educational applications. They mainly concentrate on the usability of interfaces in general but within the context of web-based e-learning:

1. **Visibility of system status**
2. **Match between the system and the real world i.e. match between designer and learner models**
3. **User control and freedom**
4. **Consistency and adherence to standards**
5. **Error prevention, specifically prevention of peripheral usability-related errors**
6. **Recognition rather than recall**
7. **Flexibility and efficiency of use**
8. **Authenticity and minimalism in design**
9. **Recognition, diagnosis, and recovery from errors**
10. **Help and documentation**

B

- **Category 2 – Website-specific design heuristics:** Although the heuristics in Category 1 also apply to web-based applications, there are others that are specific to websites as such:

11. **Simplicity of site navigation, organisation and structure**
12. **Relevance of site content to user**

C

- **Category 3 – Learner-centred instructional design heuristics:** There are further specific guidelines that have been identified throughout this study as necessary and relevant for e-learning. The heuristics in this category are grounded in current learning theories and models, and aim for effective learning within educational software applications.

13. **Clarity of goals, objectives and outcomes**
14. **Collaborative learning**
15. **Appropriateness of the level of learner control**

16. Support for personally significant approaches to learning

17. Cognitive error recognition, diagnosis and recovery

18. Feedback, guidance and assessment

19. Context meaningful to domain and learner

20. Learner motivation, creativity and active learning

Table 5.3 shows these twenty criteria/ heuristics, and for each, a number of evaluation guidelines or sub-criteria are given. In applying a heuristic, it need not be strictly limited to the guidelines given, for its use depends on the context. The right-hand column gives references for each sub-criterion, first, to the section in the dissertation, followed by a reference/s to the original source.

Table 5.3: Evaluation criteria for web-based learning

Category 1: General interface design heuristics (based on Nielsen (1994:30))		
	Criterion	**References**
1	**Visibility of system status**	
	• The website keeps the learner informed about what is going on through constructive, appropriate and timely feedback.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472); **5.3.5.1**: Levi and Conrad (1996:58)
	• For every action taken by the learner there is a visual or audio response by the system so that learners can understand the result of their actions.	**4.9.1.2**: Shneiderman and Plaisant (2005:74); **5.3.4**: Squires and Preece (1999:479)
	• The system responds to actions initiated by the user. There are no surprise actions by the site or tedious sequence of data entries.	**4.9.1.2**: Shneiderman and Plaisant (2005:74)
2	**Match between the system and the real world i.e. match between designer and learner models**	
	• The metaphor usage corresponds to that of real world objects or concepts.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)

	• Language usage such as terms, phrases, symbols, and concepts, is similar to that used by the learners in their day-to-day environment.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)
	• Use of jargon is avoided.	**5.3.5.1**: Bollaert (2002)
	• Information is arranged in a natural and logical order.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)
	• The use of multimedia, such as sound, graphics and video, for complex representation of concepts, yet without much learning content is avoided.	**5.3.4:** Squires and Preece (1999:477)
	• Cosmetic authenticity, which is a misleading match between images and the real world, is avoided. (For example, using red to show oxygenated blood and blue for deoxygenated, whereas all blood is red).	**5.3.4**: Squires and Preece (1999:474).
3	**User control and freedom**	
	• Users control the system.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)
	• Users can exit the system at any time even when they have made mistakes.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472)
	• There are facilities for ‘undo’ and ‘redo’ to provide users confidence to control the system.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472)
4	**Consistency and adherence to standards**	
	• The same concepts, words, situations, or actions refer to the same thing.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472); **5.3.4**: Squires and Preece (1999:476)
	• There is consistency in the sequence of actions taken in similar situations.	**4.9.1.2**: Shneiderman and Plaisant (2005:74)
	• There is consistency in the use of images, prompts, screens, menus, colours, fonts and layouts.	**4.9.1.2**: Shneiderman and Plaisant (2005:74)

	• Screen/page titles are consistent with page names. • Common operating system standards are followed.	**5.3.3**: Brinck and Wood (2002:410) **5.3.5.1**: Brinck and Wood (2002:411); **3.4.2**: Alessi and Trollip (2001: 374)
5	**Error prevention, specifically prevention of peripheral usability-related errors** • The system is designed such that the learner cannot easily make serious errors. • When the learner makes an error, the application gives an error message. • Procedures to fix errors are provided. • The system does not accept illegal or type mismatch values, and if such are entered the user is assisted to recover quickly and efficiently. • Menu, hyper-linked or icon-driven interfaces are used instead of a command-driven ones.	 **4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472) **4.9.1.2**: Shneiderman and Plaisant (2005:74) **3.5.7**: Powell (2001:44); **4.3.1**: Karoulis and Pombortsis (2003: 91); **4.3.3**: Dix et al (1998:172) **5.3.5.1**: Brinck and Wood (2002:411) **4.9.1.2**: Shneiderman and Plaisant (2005:74)
6	**Recognition rather than recall** • Objects to be manipulated, options for selection, and actions to be taken are visible, so that the user does not need to recall information from one part of a dialogue to another. • Instructions on how to use the system are visible or easily retrievable whenever appropriate. • Displays are simple and multiple page displays are minimised. • There are options for loading or printing pages with minimal or no graphics to allow for speedy content loading or printing.	 **4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472) **4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472) **4.9.1.2**: Shneiderman and Plaisant (2005:74); **5.3.5.1**: Levi and Conrad (1996:58) **3.5.6**: Jones and Farquhar (1997:243).

7	**Flexibility and efficiency of use**	
	• The site caters for different levels of users, from novice to expert.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)
	• Shortcuts, unseen by the novice users, are provided to speed up interaction and task completion by frequent users. They are in the form of abbreviations, special keys, hidden commands or macros.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472); **5.3.5.1**: Bollaert (2002)
	• The site is flexible to enable learners to adjust settings to suit themselves.	**5.3.4**: Squires and Preece (1999:473)
8	**Authenticity and minimalism in design**	
	• Site dialogues do not consist of irrelevant or rarely needed information, for these may distract the learners as they perform tasks.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472); **3.5.2:** Sinha et al (2001); **5.3.5.2**: Storey et al (2002:95)
9	**Recognition, diagnosis, and recovery from errors**	
	• Error messages are expressed in plain language.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)
	• Error messages indicate precisely what the problem is and give a simple, constructive, specific instruction for recovery.	**4.9.1.2**: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472); **3.5.7**: Powell (2001:44); **4.3.1**: Karoulis and Pombortsis (2003::91); **4.3.3**: Dix et al (2004:270)
	• If a typed command results in an error, the user does not have to retype the entire command, but rather to repair only the faulty part.	**4.9.1.2**: Shneiderman and Plaisant (2005:74)
	• The site provides for easy reversal of action where possible, for example, by providing both ‘undo’ and ‘redo’.	**4.9.1.2**: Shneiderman and Plaisant (2005:74)

<table>
<tr><td>10</td><td>Help and documentation

• The site has a help facility and other documentation to support the learner’s needs.

• The information in these documents is easy to search, focused on the learner’s task and lists concrete steps to be carried out to accomplish a task.

• In addition to online help, there is a section for troubleshooting, FAQs and glossaries.</td><td>4.9.1.2: Dix et al (2004:325); Nielsen (1994:30); Shneiderman and Plaisant (2005:74); Squires and Preece (1999:472); 5.3.5.1: Bollaert (2002)

44.9.1.2: Dix et al (2004:325); Nielsen (1994:30); Squires and Preece (1999:472)

3.5.7: Powell (2001:44); Wein et al (2000);</td></tr>
<tr><td colspan="3">Category 2: Website-specific design heuristics</td></tr>
<tr><td></td><td>Criterion</td><td>References</td></tr>
<tr><td>11</td><td>Simplicity of site navigation, organisation and structure

• Learners always know where they are and have options of where to go next.

• The navigational options are limited so as not to overwhelm the learner.

• There is a site search option and a site map.

• There is a link back to the home page from every internal page.

• There is consistency of links colours usage with Web conventions: blue for non-visited and green or purple for visited ones.

• Related information is placed together.

• Information is organised hierarchically, starting with general information then specific.

• Important information is placed at the top of a page to avoid scrolling to find information.

• There is a smooth flow of interaction with the application.</td><td>4.9.1.3: Barber (2002)

5.3.5.1: Bollaert (2002)

5.3.5.1: Brinck and Wood (2002:411); 3.5.4: Sinha et al (2001)

3.5.3: Maddux and Johnson (1997:5); Wein et al (2000)

5.3.3: Brinck and Wood (2002:410)

3.5.3: Powell (2001:44)

5.3.5.1: Levi and Conrad (1996: 58)

3.5.3: Jones and Farquhar (1997:241)

5.3.4: Squires and Preece (1999:475).</td></tr>
</table>

	• Common browser standards are followed.	**5.3.5.1**: Brinck and Wood (2002:411)
12	**Relevance of site content to user**	
	• Content is the information provided on the site. Content is engaging, relevant, appropriate and clear for the users of site.	**3.5.2**: Sinha et al (2001).
	• The content has no biases such as racial and gender biases which may offend some learners.	**3.5.2**: Powell (2001:44).
	• Site content and links are updated regularly.	**3.5.2**: Maddux and Johnson (1997:5); Powell (2001:44); **3.4.2**: Alessi and Trollip (2001: 374 **5.3.5.1**: Levi and Conrad (1996: 58)
	• Every document shows the date on which it was created and updated, as well as details of its author.	**3.5.2**: Powell (2001:44).
	• It is clear which materials are copyrighted and which are not.	**3.5.2**: Maddux and Johnson (1997:5).
	• The authors of the content are of reputable authority.	**3.5.1**: Powell (2001:44)
	• Records are kept of students' activities and evaluations.	**5.3.5.1**: Bollaert (2002)
Category 3: Learner-centred instructional design heuristics		
	Criterion	**References**
13	**Clarity of goals, objectives and outcomes**	
	• From the beginning of a learning encounter to the end, clear goals are communicated and available.	**3.4.3.2**: Alessi and Trollip (1991:32; Wein et al (2000).
	• Intended outcomes for each task are made explicit in advance.	**3.4.3.2**: Ritchie and Hoffman (1997:136)
	• Outcomes are measurable.	**5.3.5.2**: Albion (1999)
	• Each learning encounter or document on the site states its educational goals and objectives.	**3.2.4**: Alessi and Trollip (2001:11); **3.3.1.3**: Reeves and Reeves (1997:61);

		3.4.3.2: El-Tigi and Branch (1997:23); Ardito et al (2004); Ritchie and Hoffman (1997:136)
14	**Collaborative learning**	
	• Facilities and activities are available that encourage inter- and intra-group activities such as teamwork, group projects, group debates, discussions, collaborative problem solving and presentations.	**3.4.1**: Alessi and Trollip (2001:380); Collis (1999:213); Frantz and King (2000:33); Shneiderman et al (1998:23); **3.3.2.6**: De Villiers (2003) **5.3.2**: Squires (1999:464) **5.3.4**: Squires and Preece (1999:478)
	• Learner-learner interactions are encouraged and supported.	**3.4.1**: Vrasidas and McIsaac (2000:110) **5.3.1**: Squires and Preece (1999:471)
	• Collaborative construction of knowledge is supported through social negotiation, but not through competition among learners.	**2.2.3.1**: Alessi and Trollip (2001:32); Jonassen (1994:35-37)
	• Collaboration and cooperation between learners and educator is encouraged.	**3.2.5.2**: Hedberg et al (1997:49); **3.3.1.8**: Reeves and Reeves (1997:63); **5.3.5.2**: Vrasidas (2004:913)
	• In any collaborative learning activity, the educator acts as a facilitator, coach, mentor, guide or partner with learners, but not as a controller.	**2.2.3.1**: Alessi and Trollip (2001:32) **3.3.1.6**: Reeves and Reeves, 1997:62)
	• There are facilities for both asynchronous and synchronous communication such as e-mail, listservs, bulletin boards, discussion forums and chat rooms, using text, audio or video.	**3.3.2.6**: De Villiers (2003); **3.4.1**: Firdyiwek (1999:29); Vrasidas and McIsaac (2000:105); **3.4.3**: Alessi and Trollip (2001: 375); Costabile et al (2005:6); Wein et al (2000); **5.3.5.2**: Vrasidas (2004:913)
15	**Appropriateness of the level of learner control**	
	• Apart from controlling the interactions with the site, learners have some freedom to direct their learning, either individually or through collaborative experiences, to have a sense of ownership of their learning. Learners are given some control of what is learned, how it is learned and the order in which it is learned.	**5.3.4**: Squires and Preece (1999:478); Squires and Preece (1999:480); **2.2.3.1**: Squires (1999:464); Reeves and Reeves (1997:60); **3.4.3.8**: Khan (1997:14)

	• Learners can find their own pathways, within the site and on the Internet, in order to learn.	**5.3.4**: Squires and Preece (1999:478)
	• Individual learners can customise the site to suite their learning strategy.	**3.4.3.10**: Willis and Dickinson (1997: 83); Squires and Preece (1999:478)
	• Teachers can customise learning artefacts to the individual learner; for example, tests and performance evaluations can be customised to the learner's ability.	**3.4.3.10**: Willis and Dickinson (1997: 83)
	• Where appropriate, learners can take the initiative regarding the methods, time, place, content, and sequence of learning.	**3.3.2.5**: De Villiers (2003)
16	**Support for personally significant approaches to learning**	
	• There are multiple representations and varying views of learning artefacts and tasks.	**5.3.4**: Squires and Preece (1999:480)
	• The site supports different strategies for learning and indicates clearly which styles it supports.	**5.3.4**: Squires and Preece (1999:480)
	• The site is used in combination with other mediums of instruction to support learning.	**5.3.1**: Squires and Preece (1999:471); **5.3.4**: Squires and Preece (1999:473)
	• Learning environments are provided to learners to explore systems, environments and artefacts.	**5.3.4**: Squires and Preece (1999:477)
	• Learners are introduced to concepts, using specific tasks or problems, before they are left to learn independently.	**5.3.4**: Squires and Preece (1999:477); **2.2.2**: Reigeluth and Moore (1999:53)
	• There is recognition of the critical role of prior knowledge, since learning is the incorporation of new knowledge into the network of prior knowledge.	**2.2.3.1**: Bruner (1990); **2.2.4.1**: Mayes and Fowler (1999: 489); **3.3.2.1**: De Villiers (2003); **3.4.3.12**: Wein et al (2000); **5.3.4**: Squires and Preece (1999:473)
	• Metacognition by the learner, which is the ability for an individual to evaluate his/her own cognitive skills, is encouraged. Metacognition culminates in a learner's awareness of objectives, ability to plan and evaluate learning strategies, and capacity to monitor progress and adjust learning behaviours to accommodate his/her needs.	**2.2.2**: Reigeluth and Moore (1999:52); **3.3.1.7**: Reeves and Reeves (1997:62); **2.2.2**: Alessi and Trollip (2001:20); **2.2.3.1**: Jonassen (1994: 35); **3.4.3.11**: Vat (2001:326);

		5.3.4: Squires and Preece (1999:478); **5.3.5.2**: Vrasidas (2004:913)
	• The site supports the transfer of learned skills beyond the learning environment and facilitates the learner to self-improve.	**5.3.5.2**: Albion (1999)
	• Learning activities are scaffolded by providing support to learners to allow them to work within existing competency while encountering meaningful chunks of knowledge.	**5.3.5.2**: Albion (1999)
17	**Cognitive error recognition, diagnosis and recovery**	
	• Established strategies, such as cognitive conflict, scaffolding, bridging, and problem-based learning (PBL) are used to promote the recognition-diagnosis-recovery cycle. (This cycle also exists for interface errors as explained in Heuristic 9.)	**5.3.4**: Squires and Preece (1999:480)
	• Learners need access to a rich and complex environment where they can express their own ideas and explore different solutions to problems since people learn by their mistakes.	**5.3.4**: Squires and Preece (1999:477)
	• Learners are provided with the necessary help to recover from cognitive errors.	**5.3.4**: Squires and Preece (1999:477)
	• Learners are given opportunities to develop personal problem-solving strategies.	**5.3.5.2**: Karoulis and Pombortsis (2003:99); **3.4.3.9**: Jun et al (2002:46); Oliver (2000:6)
18	**Feedback, guidance and assessment**	
	• Apart from feedback by the system, as described in Criterion 1, there is prompt and frequent feedback from teachers and peers, using the system, for growth of understanding of the learner.	**2.2.2.1**: Mayes and Fowler (1999: 487); **5.3.5.2**: Vrasidas (2004:913); **5.3.4**: Squires (1997)
	• Learners give and receive feedback about the knowledge being constructed.	**3.2.1**: Gill (2003:21)
	• Learners are guided by the educator who challenges them with questions and provides qualitative feedback to their responses since it is not easy to learn something in a single exposure.	**3.2.3.3:** Alessi and Trollip (2001:8)
	• Guidance is given in the form of links to definitions and examples, and cross-references to relevant sections for multiple choice questions answers.	**3.4.3.6**: Ritchie and Hoffman (1997:136)

	• Quantitative feedback, in terms of grading learners' activities, is given so that learners know their performance.	**3.4.3.6:** Ritchie and Hoffman (1997:136); Wein et al (2000); **5.3.4:** Squires and Preece (1999:473); **5.3.5.2**: Albion (1999) **5.3.5.2**: Vrasidas (2004:913)
19	**Context meaningful to domain and learner**	
	• The activities in the application are situated in practice and will interest and engage learners.	**5.3.5.2**: Albion (1999); **5.3.5.2**: Vrasidas (2004:913)
	• Knowledge is presented within a meaningful and authentic context that supports effective learning.	**2.2.3.1**: Kang and Byun (2001:48); **5.3.2**: Squires (1999:464); **2.2.3.2**: Jonassen (1994:37); **5.3.4**: Squires and Preece (1999:470); **5.3.5.2**: Vrasidas (2004:913)
	• Authentic, contextualised tasks are undertaken rather than abstract instructions.	**2.2.3.1**: Jonassen (1994: 35);
	• The application enables context- and content-dependent knowledge construction.	**2.2.3.1**: Jonassen (1994:36); **5.3.5.2**: Vrasidas (2004:913)
	• Learning occurs in a context of use so that knowledge and skills learned will be transferable to other similar contexts.	**3.3.1.4**: Reeves and Reeves (1997:61)
	• Understandable and meaningful symbolic representations are used o ensure that the symbols, icons and names used are intuitive within the context of the learning task.	**5.3.4**: Squires and Preece (1999:476)
20	**Learner motivation, creativity and active learning**	
	• The application provides intrinsic motivation to learners.	**3.3.1.5**: Reeves and Reeves (1997:61-62); **5.3.5.1**: Squires (1997)
	• Learners recieve grades, physical rewards and other incentives as extrinsic motivation to learn and accomplish school requirements.	**2.2.1**: Black (1995)
	• The site motivates learners by cautious integration of music, voice, graphics, text and animation in their learning experience.	**3.3.1.5**: Reeves and Reeves (1997:61-62)
	• The application promotes creativity by engaging learners, and having innovative motivating features.	**3.4.3.3**: Ritchie and Hoffman (1997:135); **3.3.2.4**: De Villiers (2003) **5.3.5.2**: Vrasidas (2004:913)

	• In order to attract and retain learners, the application engages them by its content and interaction, and their attention is retained.	**3.4.3.3**: Ritchie and Hoffman (1997:135); **5.3.5.2**: Vrasidas (2004:913)
	• In order to motivate learners through inquiry arousal, learners encounter solved problems on the site.	**3.4.3.3**: Ritchie and Hoffman (1997:135)
	• To promote active learning, learners are encouraged to compare, analyse or classify information, or make deductions from it. • The following tactics are also used to motivate learners: o *Reinforcement*: successful end of an activity is followed by an enjoyable task, for example, a game after a lengthy tutorial; o *Challenge*: varying levels of challenge are provided to cater for different learners; o *Competition*: the learner can compete with other learners on a limited scale, or with computer-based programs, for example, by stimulating activities and quizzes; o *Session length*: to avoid boredom, activities are subdivided or chunked; and o *Variety*: display and response modes are varied, for example, use of the mouse, keyboard or touch panels in the manipulation of information.	**3.4.3.5**: Ritchie and Hoffman (1997:135) **3.4.3.3**: Alessi and Trollip (2001:204-207)

Table 5.3: Evaluation criteria for web-based learning

5.5 Conclusion

The aim of this chapter was to answer the first research subquestion of this study – namely to determine the criteria appropriate for usability evaluation of web-based e-learning applications. It is recommended that such criteria take into account both the application's pedagogical effectiveness and its usability, so that interaction with the application does not hinder learning. While there are ongoing discussions on the relationship between usability and learning, studies have shown that there is a positive correlation between usability and the performance of learners in the relevant content and tasks, and that an interface which is difficult to use affects learning performance negatively.

For many professions, there are considerable numbers of heuristics and guidelines to guide professional practice. Although considerable expertise exists on the separate issues of learning theory, usability and Web design, however, there is limited integration of these issues for web-based e-learning. In particular, there are instructional design challenges in determining how best to integrate learning theories, such as constructivism, with usability.

This chapter presented a study that integrates usability and learning and generated a set of criteria or heuristics, to cater for these two areas. Such heuristics are more appropriate to use in evaluation of an educational application than a lengthy checklist, since the latter takes more time to use, furthermore, checklists are normally application-specific.

A number of existing heuristics for general interfaces, the Web and educational design were identified in this chapter. Nielsen's classic heuristics and various other sets plus the literature surveys of Chapters 2 to 4 were integrated to generate a set of categories and criteria for usability evaluation of web-based e-learning applications. This set of heuristics/criteria forms the basis on which heuristic evaluation by experts, and survey and interview evaluations by learners are conducted, as described in Chapter 7. The sub-criteria, rather than the header criteria, are, in most cases, used to generate evaluation questions and expert heuristics.

The criteria and sub-criteria identified, can serve a further valuable purpose in their application as design principles and guidelines in the development of new applications.

Chapter 6: Web-Based Application: Development, Structure and Usage

6.1 Introduction

Development of a quality web-based learning application is more than simply placing instructional materials online. Instead, it is like designing a virtual classroom where people can learn and develop their own skills. The development process should take into account elements of graphical design, instructional design, and site design with content that meets the needs of the target learners and the goals of the educator (Dupuis, 2003:165; Ruffini, 2000:58). Elements of these have been discussed in Chapter 2 (Learning Theories), Chapter 3(Web-Based Learning) and Chapter 4 (Usability Evaluation and Methods). Chapter 5 (Usability and Learning: Heuristic Evaluation Criteria) extracts issues from these chapters and generates a set of criteria for the evaluation of WBL applications.

This chapter describes the development, structure and use of the WBL application called Info3Net, which is used as the target system in this evaluation case study. Info3Net was developed as a WBL application using a course management system (CMS), namely WebCT™. It is in line with the WebCT™ ethos and is primarily a delivery and testing mechanism, not a highly active and interactive constructivist learning application nor is it a tutorial to support cognitive learning. The objective of the study, in form of the research question in Section 1.2.1, is to investigate to what extent heuristic evaluation *can identify usability problems* in a web-based e-learning application. The target system used for evaluation need not be an ideal environment in line with e-learning best practices and the most recent theoretical stances. In summary, the purpose of the theoretical concepts in Chapters 2 to 4 was to build a set of evaluation criteria and not to build an ideal e-learning application. Although the concepts can play a valuable role in supporting designers and developers, that was not the primary purpose of this research.

In order to set the context for the Info3Net development, the next section describes the main tool used to develop it and the level of integration of this application into the teaching and learning of

Information Systems 3 at Walter Sisulu University (WSU). This is followed by on overview of some of the issues that should be considered in the development of a WBL application of this nature.

6.2 The Development Tool and Integration Level of the Application

6.2.1 Introducing WebCT™

As stated in the previous section, the main tool used by the present researcher to develop Info3Net was WebCT™. WebCT™ is a tool that facilitates the creation of web-based educational environments (Britain & Liber, 1999). WebCT™ is a subset of web-based learning software, where web-based learning software can be categorised as including the following (Jackson, 2004):

- **An authoring tool**: Such a tool is used essentially for creating multimedia. Microsoft PowerPoint™ is an example.
- **Real-time virtual classroom:** It is a virtual classroom software product or a suite that facilitates the synchronous, real-time delivery of content or interaction by the Web but does not necessarily handle course administrative tasks.
- **Learning management systems (LMS):** This is a broad term used to cover a wide range of learning management and asynchronous delivery tools, including:
    - *Course management system (CMS):* a LMS that facilitates Web delivery and management of courses, and provides integrated tools for measuring outcomes and reporting learners' progress.
    - *Enterprise learning management*: a LMS for teams of developers that provides a platform for content delivery and organisation.
    - *Learning content management systems (LCMS):* a recent form of LMS where the basic LMS features are enhanced with authoring tools that develop knowledge and database management systems.

Using this classification, WebCT™ as used in this study, can be considered to be a CMS, which is a subset of the LMS family. Vinaja and Raisinghani (2001:70) and Davenport (2005:44) also refer to WebCT™ as a CMS. However, Kazmer and Haythornthwaite (2004:7) and Widmayer (2000) refer to it as an online course management system (OCMS), which is a software package that allows an instructor to easily create course content, to provide opportunities for learning interactions and assessment, and to manage the course (Widmayer, 2000). In this study the terms OCMS, CMS and LMS will be used interchangeably to refer to the WebCT™ software that was used to develop and manage Info3Net, the WBL application for this study.

A CMS provides a set of tools from which an instructor can select when setting up a course website to facilitate teaching and learning. They include the following: (O'Leary, 2002; Widmayer, 2000):

- Templates to create a homepage;
- Tools for interactions, such as white board, discussion board, chat room and e-mail;
- Tools for assessment, such as a quiz (test) creation tool, learner presentation area and the learner's self test creation tool;
- Tools for course management, such as online grading facilities, learner tracking and a course calendar;
- Tools for availing and organising course content to facilitate delivery of learning resources and material;
- Support tools for learners, for example, a glossary, index and search tool; and
- Student tools, such as those that allow learners to create their own Web pages within the application, and to upload course work.

WebCT™ has these features built into it. This, too, qualifies it to be a CMS.

6.2.2 Info3Net Integration Level

Info3Net was developed to supplement face-to-face classroom instruction. Singh (2003:52) refers to this as "blending offline and online learning" where, for example, the application provides study material and research resources over the Web while also having instructor-led classroom sessions as the main medium of instruction. This approach, which was used in this study, is described as *technology-enhanced learning*, as opposed to *technology-delivered (distance) learning* (Jackson, 2004). Technology-enhanced learning has the following characteristics (Jackson, 2004):

- Learners have frequent opportunities to meet with the instructor;
- It supplements, and usually is subordinate to, face-to-face classes;
- Instructor-led sessions are live contact sessions in traditional classrooms; and
- The technological aspects are usually asynchronous and implemented through a Web editor or a CMS.

In line with this, the Info3Net WBL application for Information Systems 3 at WSU was developed to supplement face-to-face contact (classroom) teaching. The development tool used was WebCT™ in its role as a CMS. The main goal of developing a WBL application using a CMS is to manage the learners, and keep track of their progress and performance across all areas of learning and teaching (Granic et al, 2004).

The decision to use a CMS was taken due to its many advantages in designing web-based e-learning, including the following (Widmayer, 2000):

- It is easy to set up web-based learning environments and add further interactivity without learning advanced programming skills.
- Course management systems provide productivity tools such an online grading facility, calendar and student tracking to help educators manage and monitor courses smoothly.
- They support downloading of all the online support into a single password-protected space. Apart from convenience of use for learners, this provides a collaborative learning environment, while protecting the learners’ rights to privacy.

The next section overviews some of the issues to consider when developing a WBL application, and makes cross reference to relevant aspects already discussed in this study.

6.3 Aspects to Consider in Web-Based Learning Development

6.3.1 Development expertise

As discussed in Section 6.1, development of WBL applications does not merely entail placing instructional materials online. The process requires knowledge of instructional and graphical aspects, as well as basic Web design expertise. Other challenges are that every online course is unique, due to factors such as its goals, content, audience, and budget (Vrasidas & McIsaac, 2000:106). The development process requires much more time in planning and structuring than traditional instruction (Vrasidas & McIsaac, 2000:109). Designers of WBL applications should be knowledgeable in a range of areas, know what they want to achieve in terms of teaching and learning, have sufficient financial backing and set aside enough time for development and maintenance of the applications. Planning is critical if success is to be attained.

Planning of WBL projects requires knowledge of educational theory (Dupuis, 2003:1) since the development of learner-centred technology requires an underlying theoretical approach to learning (Quintana, Krajcik, Soloway & Norris, 2003:826). In cognisance of this, learning theories in general were discussed in Chapter 2, and learning theories and models in the particular context of e-learning were discussed in Chapter 3. In particular, Section 3.4.3 puts forward guidelines that should be considered for web-based learning.

The three major aspects to consider in educational design are the teacher, the learner and the domain knowledge the learner should acquire (Kotze & De Villiers, 1996:69). In support of this, Granic et al (2004) suggest that in designing a LMS one should consider what to teach (domain knowledge), the way to teach it (teacher knowledge) and who should be taught (learner knowledge). The learner and educator are discussed next.

6.3.2 The Learners

Learners are the main target of any learning environment. It is important that the application developer knows the general characteristics of the target learners. Some of the issues to consider include age, affiliation, Internet access, technological skills, educational needs, culture, interests, motivation, and expectations of the learner (Flower, 2003:37). These issues have been addressed in the different sections of this study, particularly in Sections 3.3 to 3.5.

In addition to the foregoing issues with relation to learners, one can investigate whether it is viable to have a web-based course by asking the following questions regarding the target group (Vrasidas & McIsaac, 2000:106):

- Do the learners have the required computers and access to the Internet?
- Do they possess the basic knowledge of how to use computers?
- What are their levels of experience in browsing the Internet, using electronic mail, engaging in computer conferencing and downloading files?
- How much background do the learners have about the subject matter of the course?
- What is their attitude towards the subject and the delivery medium?

6.3.3 The educator-designer

The teacher or educator, who is often also the designer, plays a critical role in the generation of any e-learning application. In determining what to teach and how to teach it, the role of the course designer involves (Vrasidas, 2004:913):

- Designing the overall structure of the course, relationship to the syllabus, and other aspects relating to the smooth running of the course;
- Determining the learner activities, for example, assignments, online discussions and debates; and
- Selecting the learning strategies and appropriate media that will assist the learners to achieve the required outcomes.

Apart from considering what to teach and how to teach it, the teacher as the educator-designer of a WBL course has duties to perform in the roles of administrator, manager, evaluator and moderator (Vrasidas, 2004:913):

- **Administrator and manager:**
  - Monitor course registration, maintain records, and ensure security of the information and work; and
  - Establish and discuss with the learners rules to be followed in the activities.
- **Evaluator:**
  - Prepare assessment criteria in line with the learning outcomes and goals;
  - Ensure that learners receive timely and constructive feedback;
  - Keep records, including results of assessment, and monitor learners' progress; and
  - Ensure that the work submitted is authentic and the learners' own work.
- **Moderator:**
  - Establish clear goals, structure, activities and expectations for online discussions; and
  - Use different techniques, such as collaborative projects, debates and group discussions, to ensure that all learners participate in online discussions.

The manner in which some of the issues in this section were dealt with in this case study will become apparent in the next two sections, 6.4 and 6.5 as the study moves on from generic principles to the particular development of Info3Net. Section 6.4 deals with the actual design and components of the Info3Net. Section 6.5 describes how it was used.

6.4 Design and Structure of Info3Net

A structured methodology should be adopted in the development of any application. The approach used in developing Info3Net, takes into account that a CMS, namely WebCT™, was used. As discussed in Section 6.2, a CMS software package enables an instructor to create courseware, to provide opportunities for learning interactions and assessment, and to manage the course. In this context, a conventional systems development methodology consisting of planning, analysis, design, implementation, and operation and support phases (Shelly, Cashman

& Rosenblatt, 2001:18) may not be directly appropriate; however, some form of methodology still needs to be used. Table 6.1 shows the steps/phases suggested by Li (2003) for the development of a web-based application using WebCT™. It is important to note that the template does have certain elements of a conventional systems development methodology. For example, Step 1 has elements of planning and analysis, Step 2 is concerned with design issues, and Steps 3 and 4 deal with implementation issues.

Step 1: Reflect on classroom instruction and identify course activities that can be enhanced/expanded by WebCT™.
Step 2: Design web-enhanced activities and select WebCT™ tools.
Step 3: Build the site in WebCT™.
Step 4: Test/Evaluate.

Table 6.1: Steps to build a Web-enhanced course (Li, 2003)

A related approach for the development of WBL using a CMS such as WebCT™ is suggested by Dupuis (2003:167) who proposes an iterative design process including the following steps:

- Articulate goals and objectives;
- Select instructional approaches;
- Select general site architecture;
- Organise site content for each component, module, or subsection;
- Test the prototype site; and
- Review and revise site.

These steps and those in Table 6.1 are similar.

Table 6.1 is used as a template for an outline of the design and content of Info3Net. Under Li's (2003) steps, descriptions are given of what was actually undertaken. This is done in Sections 6.4.1 to 6.4.4, which correspond respectively to Li's steps.

6.4.1 Reflect on classroom instruction and identify course activities that can be enhanced/expanded by WebCT™

This step should comprise the following stages (Li, 2003), which are listed below and then described in the next four subsections:

- Identify the advantages offered by WebCT™-enhanced courses;
- Reflect on the current class activities;
- Identify activities to be enhanced by WebCT™; and
- Identify activities to be expanded by WebCT™.

6.4.1.1 Identify the advantages offered by WebCT™-enhanced courses

This step considers the advantages of WBL applications, especially when used to complement face-to-face instruction. Some of these have been discussed in this study, particularly in Section 3.4.1. The advantages include (Li, 2003):

- Easy access to course materials by learners at any time;
- Improved class interaction among learners and educator via mail, discussions and chat;
- Enhanced learner-content interaction via self-tests and quizzes;
- Resources in the form of Web links to materials in collections around the globe;
- Use of multimedia such as text, graphics, audio and video;
- Availability of updated materials and announcements on the site;
- Capability to connect learners to outside experts, for example by use of video conferencing;
- Extended learning experience outside the classroom; and
- Ease of class management, for example, in terms of maintaining course records.

Most of these were taken into consideration when developing the application.

6.4.1.2 Reflect on the current class activities

Apart from general class information, cognisance should be taken of activities before (pre), during and after (post) class instruction. Pre-class instructional activities help learners to recall prior knowledge and motivate them to acquire more. During-class activities present new knowledge and skills. Post-class activities test whether learning outcomes have been achieved. It is important to note that not all activities can be enhanced by WebCT™ and only appropriate ones, according to the subject content and teacher's instructional style, should be considered (Li, 2003).

It is during this reflection phase that the different learning theories as discussed in Section 2.2, such as constructivism, are considered. The pre-, during- and post-class activities relate to the phases in the instructional model discussed in Section 3.2.3, namely presentation, guiding the learner, practising and assessing learning, which should be considered too. Appropriate methodologies for interactive multimedia that facilitate learning (as discussed in Section 3.2.4) should also be investigated.

The activities considered in the design of Info3Net are set out in Table 6.2 in the next section.

6.4.1.3 Identify activities to be enhanced by WebCT™

Table 6.2 shows activities suggested by Li (2003) and the actual activities that were considered and identified as those that could be enhanced by WebCT™.

6.4.1.4 Identify activities to be expanded by WebCT™

A WBL site developed using a CMS such as WebCT™ can be used to expand course activities by making it more engaging and building an online learning communality (Li, 2003). Table 6.3 shows some of ways in which this can be done. Due to the fact that this was the first version of Info3Net, these were not considered in its development at this stage.

Activities	**Suggested activities (Li, 2003)**	**Actual activities in Info3Net**
Class general information	Handouts (e.g. syllabus, course schedule) Class contact information Learner attendance on site Grade book	Syllabus of Information Systems 3 Class contact information (educator's and learners' e-mails) Learner attendance on site Grade book (mark list)
Pre-instruction activities	Brainstorming Introduction of topic Summary of prior knowledge	Introduction of topic (overview)
During-instruction activities (Presentation)	Lecture notes Slide shows Course readings	Course readings (course content)
During-instruction activities (Practice)	Discussion Collaborative learning activities (e.g. small group, team work) Debate Case study	Discussion (using discussion tool)
Post- instruction activities	Self-test (multiple choices/short answers) Research paper (access to information and submission of paper) Problems (publish solutions and answer learners' questions) Tests and exams (deliver online tests/exams)	Self-test (multiple choices/short answers) Problems (publish solutions and answer learners' questions) Tests (deliver online tests)

Table 6.2: Suggested and actual activities of the WBL site

Activity	**Example of implementation**
Invite distant field experts to the class	Invite a distant field expert to class via WebCT™. Such a guest can be given login access to the site for his/her contributions.
Perform Web Quest activities – Web research project	Learners can be asked to do a research project and present it in the form of Web pages on Info3Net.
Create a course research centre	The educator and learners can work together to create an on-site resource centre. The educator can collect resources from the learners and publish them on Info3Net.
Display simulations	Display simulations, such as a simulation of the object-oriented database structure, using Info3Net to help learners understand certain abstract concepts.

Table 6.3: Course activities expanded by WebCT™

6.4.2 Design web-enhanced activities and select WebCT™ tools

This step should comprise the following stages (Li, 2003), which are elaborated in the next two subsections:

- Identify the role of the Web in course activities: delivery level or integrated level; and
- Design web-enhanced activities and select appropriate WebCT™ tools.

6.4.2.1 Identify the role of the Web in course activities: delivery level or integrated level

Li (2003) advocates precise identification of the role of the Web in course activities by determining the level of the functionality implemented. The two levels are (Li, 2003):

- **Delivery level:** This is where the Web is used as a one-way information delivery medium with limited two-way communication between educator and learners. For example, it is used to make announcements, publish grades and provide course handouts, not to assign grades to activities done on the site.
- **Integrated level:** In this level, the site is specifically designed to be an indispensable and integrated part of instruction and learning. Activities to enhance two-way course interactions are usually assigned a mark automatically by the system. For example, learners will do graded tests on the site, and/or educators may require them to work collaboratively on a project, using the site as a means of communication.

As already stated in Section 6.2, Info3Net functions as a supplement to the face-to-face environment, and it can thus be classified as being at a delivery level. However, it has some elements of the integrated level; for example, tests are done and graded on Info3Net.

6.4.2.2 Design web-enhanced activities and select appropriate WebCT™ tools

Having reflected on classroom instruction and identified course activities that can be enhanced/expanded by WebCT™, as in Section 6.4.1, and having decided on the level of involvement of the Web, addressed in Section 6.4.2.1, the tools to be used can be identified and the activities designed.

Table 6.4 shows the actual activities in Info3Net that were identified in Table 6.2 for enhancement by WebCT™ and maps them against the tools recommended and the tools used.

Actual activities	**Recommended WebCT™ tool (Li, 2003)**	**Tool used in Info3Net**
Syllabus	Single page or Syllabus tool	Single page
Class contact information (educator's and learners' e-mails)	Mail	Mail
Learner attendance on site	My progress	My progress
Grade book (mark list)	My grade	My grade
Introduction of topic (Overview)	Single page with audio/video components in Content Module	Single page with text only in Content Module
Course readings (additional course content)	Single pages and Discussions	Single pages (In the Content Module) and Discussions
Discussion (using discussion tool)	Discussion and Assignment	Discussion and Assignment
Self-test (multiple choices/short answers)	Self test	Self test
Problems (publish solutions and answer questions)	Single page, Mail and Discussions	Single Page
Tests and exams (deliver online tests)	Single page and Quiz	Quiz

Table 6.4: Recommended and used WebCT™ tools for the WBL site – Info3Net

6.4.3 Build the site in WebCT™

The following should be undertaken in this step (Li, 2003):

- Develop course structure;
- Develop and load files; and
- Build discussions, quizzes and assignments.

These are described in the next three subsections.

6.4.3.1 Develop course structure

This section describes the structure of the Information Systems 3 website, Info3Net, that was developed as part of this research and evaluated in a case study. Explanations are given of some of the issues considered in the process of developing the structure, along with some screen displays as illustrations.

With learning and usability as the main areas of this study, instructional design issues for e-learning were considered (discussed in Chapters 2 and 3), as well as issues of usability and Web design (discussed in Chapter 4). These played important roles in the design of Info3Net. Not all the aspects overviewed in these areas were implemented in the development of Info3Net, since this was not the aim of the study, as stated in Section 6.1. However, where feasible, recommended features and facilities were incorporated. Since the main purpose of this study is a comparison of evaluation techniques, any Web-based e-learning application, not necessarily developed by the researcher, could in fact have been used.

It is important to note that when designing WBL sites, both the macro (overall site architecture) and micro (individual page) levels should be considered. The macro level deals mainly with navigational issues such as the paths taken by users to meet their goals, the site map structure, and how to use external links without leaving the main site. Apart from determining what should be on each individual page, micro level considerations such as the consistency of pages should be taken into account (O'Hanlon, 2003:225). These and other Web design factors discussed in this paper, especially in Section 3.4.3, were considered during the development of Info3Net. Figure 6.1 shows the structure of Info3Net.

As can be seen from the site structure in Figure 6.1 and the *Home Page* screen in Figure 6.2, the home page is at Level 1 of the site. It contains six links to other pages. A more detailed description of site components and their usage is given in Section 6.5.

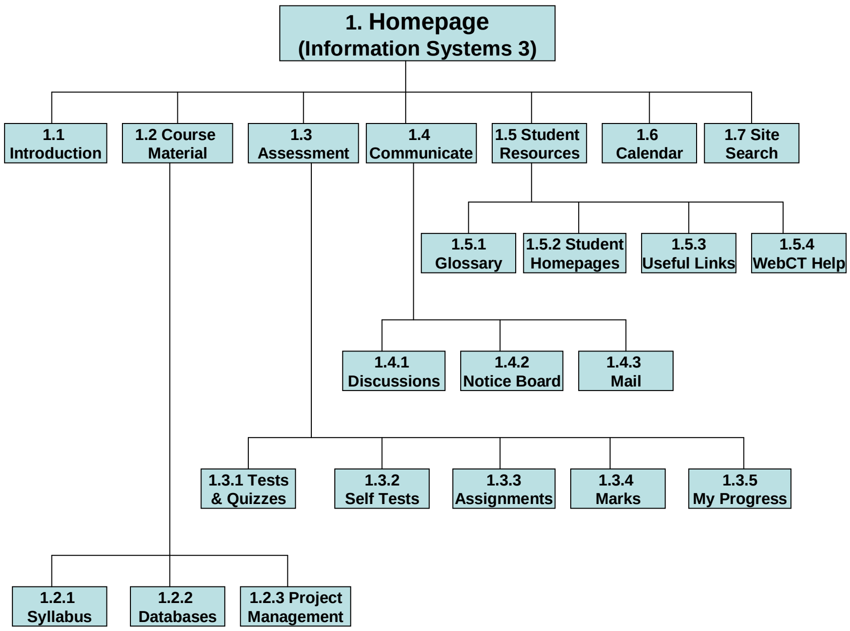

Figure 6.1: Info3Net structure

The first item on the home page is *Introduction* since it is assumed that any first-time user needs to know what the site is about. *Site Search* and *Calendar* are also at this level, since users are likely to use them frequently. *Course material*, *Assessment, Communicate* and *Students Resources* are links from the home page to Level 2 pages that consist of other links. The nomenclature and structure of the site were influenced by some of the best – according to WebCT (2003) – of the courses developed using WebCT^{TM}. For example, Figures 6.3 and 6.4 show the icons and labels used on the home pages of two of the so called “Exemplary Course Projects”, which are courses selected annually by the WebCT^{TM} company, as projects that model best practices in course design, interaction and collaboration, assessment and evaluation, meaningful technology use and learners support (WebCT, 2003).

Figure 6.2: Home Page of the Information Systems 3 website

Figure 6.3: Icons and labels on the home page of GUI Building e-Learning site (Danchak, 2003)

Figure 6.4: Icons and labels on the home page of Living Belief e-Learning site (Grahams, 2003)

As described in the previous paragraph and depicted in Figure 6.1, Course Material, Assessment, Communicate and Students Resources are at Level 2 of the site. The rationale for each of their content is explained as follows:

- **Course material**: The Course Material page is given in Figure 6.5. It consists of items that are related to the course content, including syllabus which lists the entire course content. *Databases* links to the content of the Databases module. Though a link exists for the *Project Management* module, no real content was included here at this stage. As already stated, a more detailed description of the components and their usage is given in Section 6.5.

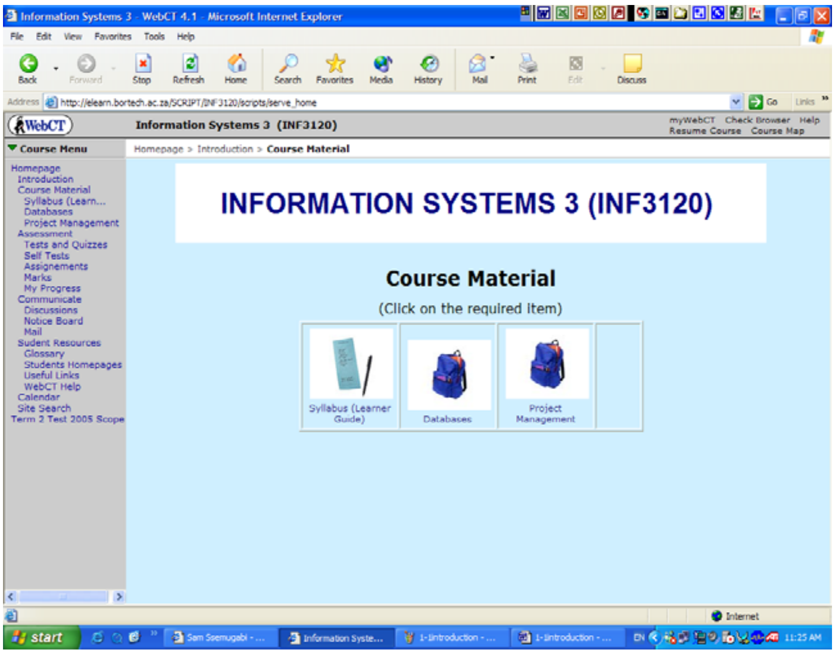

Figure 6.5: Course Material page

- **Assessment**: This page is portrayed in Figure 6.6 and is where all resources associated with assessment are found. They include *Tests and Quizzes*, *Self Tests*, *Assignments* – for uploading and downloading assignments, *Marks* – where learners can view their marks and *My Progress* – a tool that records the frequency of visits to the different pages of the site.

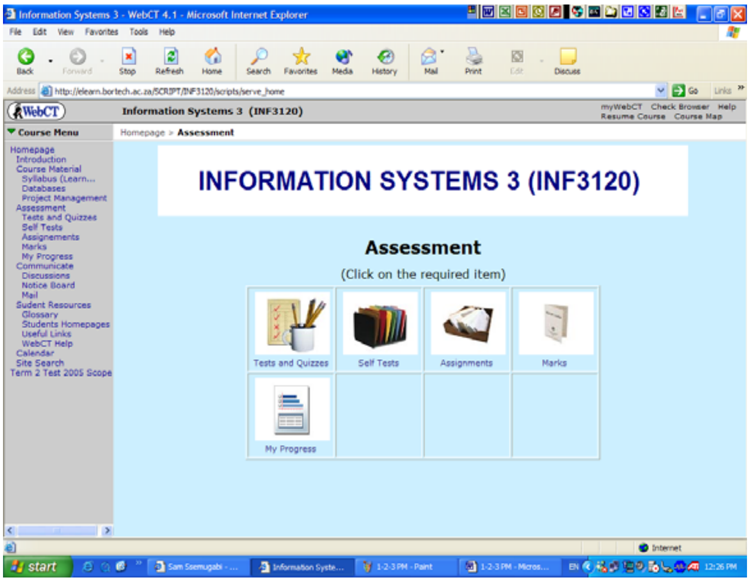

Figure 6.6: Assessment page

- **Communicate**: This page presents the communication tools, namely: *Discussion*, *Notice Board* and *Mail*, and is shown in Figure 6.7.

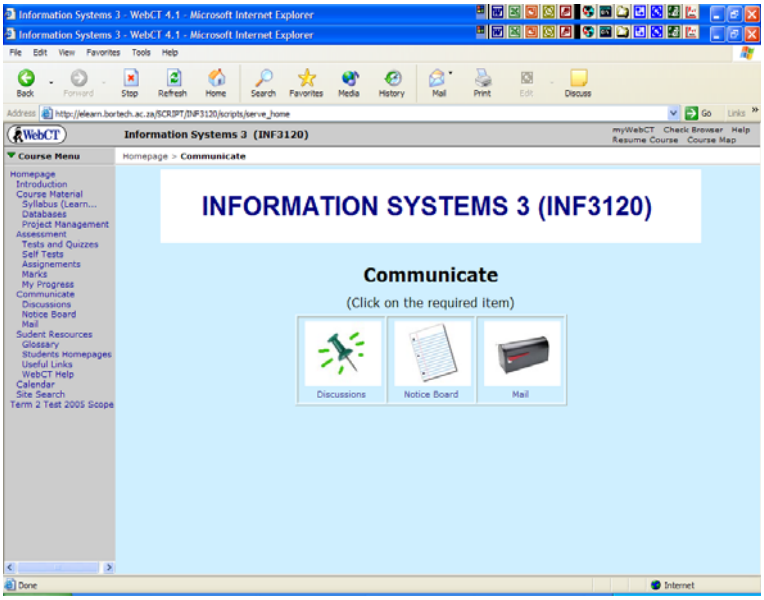

Figure 6.7: Communicate page

- **Students Resources**: This page consists of the other resources, namely: *Glossary*, *Student Homepages*, *Useful Links*, and *Help*, that were considered to be useful to the learner but are not found elsewhere on the site. It is shown in Figure 6.8. Student Homepages is a tool that allows learners to develop their own site within Info3Net using WebCT^{TM} tools. Useful Links is a link to a Level 3 page which provides some links to other sites. It is portrayed in Figure 6.9.

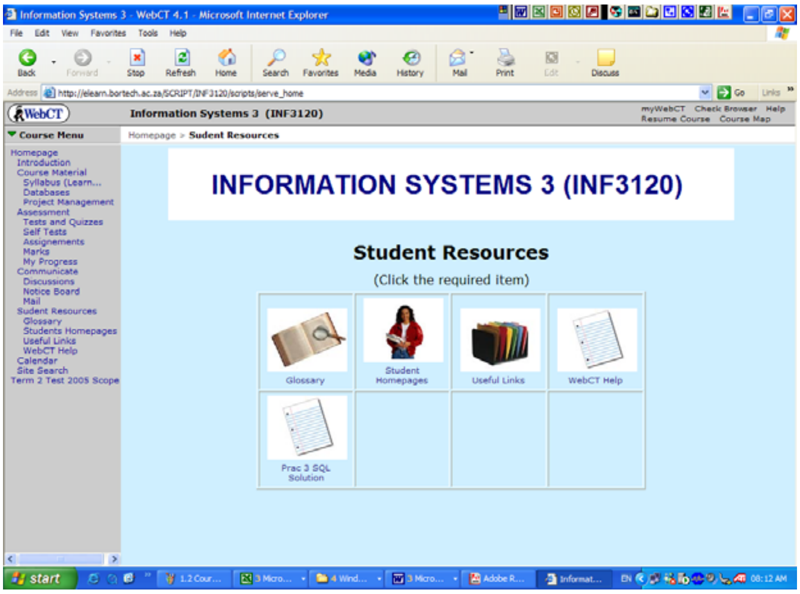

Figure 6.8: Student Resources page

Another feature of the site in relation to site navigation is the *Course Menu*. This is found consistently on the left side of the each page, including the home page, and serves as a site index. It has links to the other pages of the site. It is shown, on its own, in Figure 6.10.

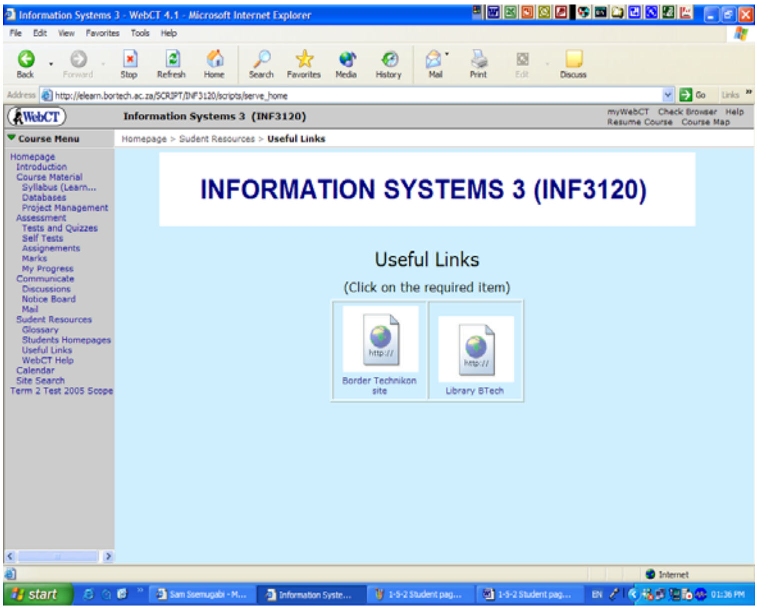

Figure 6.9: Useful Links page

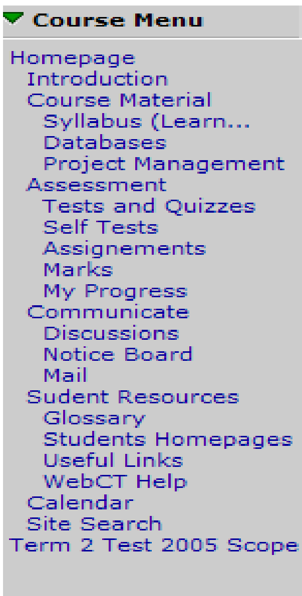

Figure 6.10: Course Menu

The Course Menu can be enabled or disabled, depending on the preference of the user. This is done by clicking on the arrow on the left of its label. Unlike Figure 6.2, where the menu is enabled, Figure 6.11 shows the Home Page with the Course Menu disabled.

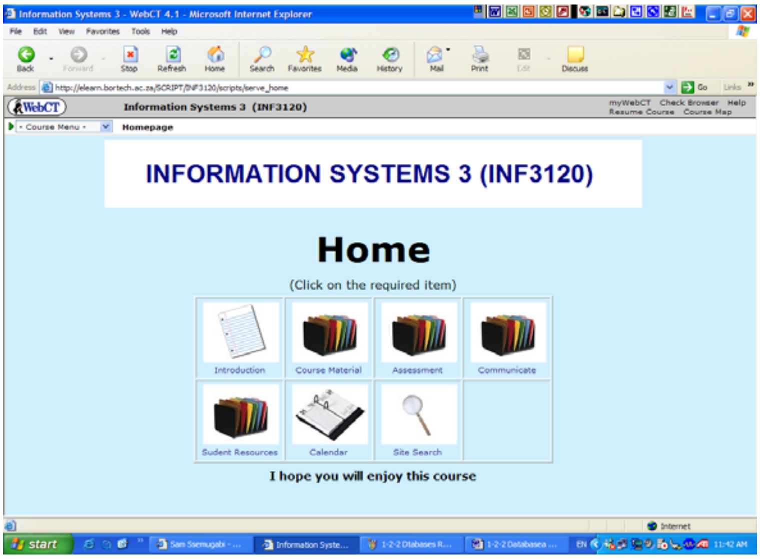

Figure 6.11: Home Page – without the Course Menu

Another important feature of Info3Net's navigation is the use of breadcrumbs. Breadcrumbs show the user's location in a site and provide links to previous pages accessed (Lingard & Waring, 2005). Figure 6.12 shows breadcrumbs when the user is on the Self Test page. The particular breadcrumb trail,

Homepage>Assessment>Self Tests,

indicates that to reach the Self Test page, the user moved from the Home Page to the Assessment page, and then to this page.

Another design decision was the choice of icons. Icons can be custom-built according to the designer's choice, for example, the icons used in Figures 6.3 and Figure 6.4. In this case, however, it was decided to use the WebCT^{TM} default icons. For example, Figure 6.13 shows the default icon for an Organiser Page. An Organiser Page is a structural page used for holding links to other pages or tools (Lingard & Waring, 2005).

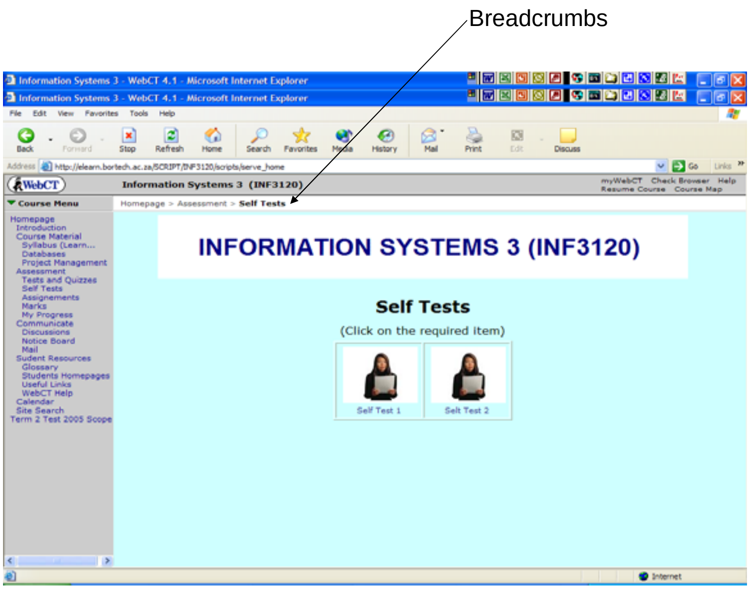

Figure 6.12: Breadcrumbs in WebCT™

On Info3Net, this tool and its default icon was used where a link points to a page with other links. All other icons indicate a direct link to a particular resource. For example, on the home page (see Figure 6.11) Introduction, Calendar and Site Search link directly to these respective resources; however, the rest of the icons, with the Organiser Page icon, link to pages that contain other links. This approach was used consistently in the design of the site.

Figure 6.13: WebCT™ Organiser Page icon

6.4.3.2 Develop and load files

Most files in WebCT™ should be in HTML format. A Web editor such as Dreamweaver™ or FrontPage™ is frequently used to develop these files (Li, 2003). In the case of Info3Net, FrontPage™ was used to develop new files; however, documents that were already in MS Word™ format were saved in HTML format and used. The Syllabus was developed using the latter approach. It is important to note that WebCT™ does not open non-HTML files. Files developed using other applications such as MS Word™ (doc) or Adobe Acrobat™ (pdf) can only be opened if the user's computer has that particular application loaded.

6.4.3.3 Build discussions, quizzes and assignments

Five quizzes corresponding to the five sections in the table of contents in the Content Module for the Databases Module, were designed and entered into the system. A single discussion topic was entered into Discussions at the start. Since assignments already existed in printed format for the entire Database module, these were not loaded into the system.

6.4.4 Test and evaluate

A website should be tested to ensure that it functions as intended. Two actions that should always be undertaken, and which were actually done during testing and evaluation of Info3Net are (Li, 2003):

- Whenever a course developer/educator changes or updates a site, he/she must make these changes or additional functionality available to users by using the 'Update Student View' button on the Control Panel; and
- The designer must always log in as a learner to test the site element/s that has/have been added or modified.

In addition to this, Table 6.5 gives a summary of what should be checked and indicates whether this was done or not.

Elements to check	How to check (Li, 2003)	In case of Info3Net
Student view	Log in as a student and check that all the site content is viewable and available to the learners. This should not be overlooked since the 'View' option available to a designer is not the same as logging in as a learner.	Done.
Assignments	Check that all assignments have been released to the students with the right dates and times.	Done.
Discussions	Ensure that all postings are accurate.	Done.
Quizzes/Tests	Check that all quizzes/tests are available to learners at the right dates and times. The designer should attempt each quiz when logged in as a learner.	Both done. The numbers of attempts that learners can make was also checked.
My Grades (Mark Records)	Log in as a learner and check that the columns for the grades that should be visible to the learners are actually visible. If they are not, log in as a designer and select the 'Release the columns' option under 'Manage Students'.	Done.
Content and Spelling	Check that all content is complete and accurate. Rectify any spelling errors. Check that all links are working.	All three were done. Spelling and syntactic errors were corrected.

Table 6.5: Recommended and actual checks done on the WebCT^{TM} WBL site – Info3Net

6.5 System Usage

6.5.1 Course details and learner profiles

Information System 3 is a third-level one-year subject at WSU that covers Database Systems in the first semester and Project Management in the second. There were about 80 learners registered for this subject in 2005 when the usability evaluations were done. All of them were in their final year of the National Diploma in Information Technology or National Diploma in Financial Information Systems. The site was mainly used by learners in the first semester, since the project Management module done in the second was not electronically functional in 2005.

From the first year level of these two Diplomas courses, approximately half the activities undertaken by learners involve computing in laboratory-based exercises, projects and presentations. By the third (final) year, each learner has completed at least one course in programming, database design and basic PC hardware and software. They are highly computer literate, and comfortable with using Microsoft Windows™ (up to XP) operating systems and Microsoft Office™ (Word™, Excel™, PowerPoint™ and Access™). They are also competent with web-based systems, using Internet Explorer™ as the browser, and e-mail, especially GroupWise (client- and web-based). These learners can be classified as expert computer users and, as such, no formal training was given on how to use Info3Net, although it was their first experience of a system designed using WebCT™. However, basic instructions on how to use the system were given to them. They mainly used the system on campus, since about 60% of them lived in campus residences and the rest did not have computers at home. The workstations in the laboratories were accessible to learners even during evening hours, likewise the system was available on- and off-campus at any time.

6.5.2 System components usage

Learners were free to use the site in the way of their own choice. Apart from using the different site components, such as the Help system and Search tool, they were compelled to read the contents of each of the five units in the Database module, and then do an online test for each. Each unit corresponded to material undertaken in contact sessions. The content on the Web was, however, not identical to what was done in class, since it is intended to supplement class learning. Only after a unit had been done in class, would the online test be taken. Most questions on the website, mainly multiple choice questions, were based on the site content. These tests contributed to the learners' year marks, though at a low weight. The normal paper-based class/term tests were done as scheduled and these contributed substantially towards the year marks.

Reading the content and doing the corresponding online tests were the main activities performed by learners using Info3Net. However, learners also used the other features of the site. The next subsections describe the site components and their usage. The subsections correspond to the links on the home page.

6.5.2.1 Introduction

This is similar to what is often termed the ‘About…’ page on a website. It is a single page about the course. It introduces the course and includes names of the modules, the lecturers and their contact details.

6.5.2.2 Course material

This links to a page with the Syllabus, Database module and Project Management module.

- The Syllabus, also referred to as the ‘Learner Guide’ in the institution, is the official university document given to each registered learner of a course. It includes, among other things, the course goals, the content of the different units of the module and the learning outcomes of each module.
- The Database module includes five units on databases, each with its objectives and content. The way the content is used was described at the beginning of Section 6.5.2. It should be noted that most of the content is presented in the form of discussion question on the topics and their possible solutions.
- The Project Management module is left blank, since this module is done in the second semester and the present researcher was not available for lecturing at the beginning of the second semester of 2005. It was included in the structure as a dummy for future uploading of content.

6.5.2.3 Assessment

This includes links to Tests & Quizzes, Self Tests, Assignments, Marks and My progress.

- Two review quizzes were included for the learners to try on their own. The questions covered all the units of the module. These were intended to give the learners a feel of how the quiz system worked. Five other quizzes, used as official tests for each of the Database module units, were included and used as described in Sections 6.5.2.

- Two Self Tests were available for learners to try independently at any time for an unlimited number of trials. These were designed to test the learners' knowledge and skills.
- Only one official assignment was placed on the site to serve as a test case, since paper-based assignments had already been printed.
- Marks: this is where learners check for their marks obtained in tests done on the system.
- My Progress: learners use this to determine how many visits they made to the different sections of the site.

6.5.2.4 Communicate

This has links to Discussion, Notice Board and Mail.

- Discussion: a few topics were initiated by the course co-ordinator (the researcher). Little response was received since use of this facility was optional. In class, learners were advised to use Discussion to discuss their projects, but it was not compulsory. They seemed to prefer face-to-face interaction with their team members and educator.
- Notice Board: this is where announcements and notices to learners were posted. Only two notices were placed, since there were few notices common to the two groups who used the site. Furthermore, the notices uploaded were duplicated on the normal departmental notice board, since it was feared that some learners would not check the online notice board regularly.
- Mail: the e-mail facility is useful for asynchronous communication among learners and educator. The facility was originally disabled since learners had the institution's e-mail facilities and once it was enabled no learner used it. Had it been available from the start, it is possible that learners would have used it instead of the alternative.

6.5.2.5 Students Resources

This link accesses resources not available on other parts of the site, but that were considered to have value for learners. The facility includes links to Glossary, Student Homepages, Useful Links and WebCT^{TM} Help.

- Glossary: provides definitions for some of the course terminology. A small number of terms were included.
- Student HomePages: this can be used by learners to create their own websites within Info3Net using WebCT^{TM} tools. This facility was originally disabled since it was not clear as to how learners would use it. When the facility was enabled later on in the course, only one learner used it. For the future it holds potential for learners to upload web-based projects and, ultimately, to develop their own online portfolios.
- Useful Links: this facility includes links to sites outside the application. Links to resources within the university's Intranet were included, since learners do not have Internet access during normal academic hours. The links included were to the library and the home page of the university.
- WebCT^{TM} Help: since WebCT^{TM} provides help to users when they log in, this facility was originally meant to connect to this built-in WebCT^{TM} help. This was, however, not done, because the built-in link was in fact visible to the users.

6.5.2.6 Calendar

This is where dates and times for important course events are provided. This facility was rarely used, since one could not be sure that the learners would visit it regularly; moreover each learner had a hard copy of the course schedule. Should the course gravitate more to an electronic presentation, this facility would play an important role.

6.5.2.7 Site Search

This is used to search for content on the site by means of key words entered by the users. A number of learners used this facility.

6.6 Conclusion

The design and development of web-based e-learning applications requires Web design skills, content knowledge, and instructional design expertise. Elements of these have been discussed in the previous four chapters. To some degree, these elements were taken into consideration and had an influence on the development of Info3Net, the first version of WBL application used in this study. This was because the objective of the study was not to integrate these but to investigate to what extent heuristic evaluation can identify usability problems.

This chapter describes the development, structure and usage of Info3Net in order to explain what it is, how it was developed and how it was used. Although there are different ways of using e-learning applications, Info3Net was used to supplement face-to-face contact teaching. WebCT™, a course management system, was the main development tool used. A brief overview was given early in the chapter of the issues that need to be considered in developing a WBL application, particularly in the case of using a CMS such as WebCT™.

It was recognised that some form of system development methodology should be followed in the development of the application. A template that includes identification of the class activities; identifying the tools and structure needed; and building, testing and evaluating the application, was used in designing Info3Net. Diagrams and screen displays were provided to illustrate and elaborate the rationale behind the structure and to explain other features of the site.

In terms of system usage, a description of the course and learner profile is given in order to contextualise the environment in which the system was used. This is followed by a description of how the learners and, to some extent, the educator, used the different components of the system. Apart from the activities where use of the system was compulsory, for example, online tests that contributed towards year marks, learners made use of the other site features.

Chapter 7: Evaluation of Application: Survey and Heuristic Evaluation

7.1 Introduction

Educational software, just like any other software, needs to be evaluated. While traditional software is normally evaluated for the efficiency and usability of its interface, educational software also needs to be evaluated in terms of how well it supports learners in learning (Quintana et al, 2003:833).

As stated in Section 1.1, a number of usability evaluation methods exist. The major methods are discussed and compared in Chapter 4. This study seeks to determine the extent to which the findings of heuristic evaluation (HE) by experts and survey evaluation among learners correspond, so as to investigate the effectiveness and sufficiency (see beginning of Section 1.6) of HE in a particular situation. As stated in Section 1.6.1, in case study research a range of different evidence is collected and collated using a number of methods. This approach of using multiple methods and several data sources, which is referred to as triangulation (see Sections 1.6.1 and 4.10.3), is applied in this study. For the evaluation among learners, a questionnaire survey and interview evaluations are undertaken; while in the heuristic evaluation by experts, criterion-based evaluation using the synthesised set of criteria is conducted, as well as follow-up severity rating on a final, consolidated set of problems. The target e-learning application is therefore evaluated using two major UEMs, each with sub-methods. This chapter describes the two methodologies and in a comparative case study, their results are analysed and compared.

7.2 Survey Evaluation among Learners

In Section 4.8, interviews and questionnaires are identified as the major techniques in usability evaluation methods that involve querying users. In this case study, a survey among the users of the application used as a target system, namely the learners, was carried out using questionnaires to evaluate its usability. This was supplemented with a focus group interview. As pointed out in

Section 1.6.1, a survey can be made using all the members of the population and this was the approach taken in this study.

The main phases of the survey evaluation among learners were the following:

- Questionnaire design;
- Pilot study;
- Actual evaluation; and
- Focus group interview.

These will be discussed in the next sections, 7.2.1 to 7.2.4 respectively. Section 7.2.5 then gives the survey results and discussion.

7.2.1 Questionnaire design

According to Gillham (2000b:15) the starting point for developing a questionnaire is to determine its broad aims and, stemming from these, to determine specific questions that need to be answered. In this study the aim was to evaluate the usability of the e-learning application, Info3Net, in particular, by identifying usability problems.

In terms of the structure and nature of questions to ask, the guidelines in Section 4.8.2 were followed. These entail starting with general questions regarding basic demographic information and facts about the respondents' experience, followed by specific questions relating to the application being evaluated. Most statements were based on the sub-criteria in Table 5.3. However, the sub-criteria were, in some cases, rephrased or partitioned to suit the learners' level of comprehension. Learners were required to provide their personal details, experience in using computers in general, and exposure to web-based and other types of e-learning applications.

The questionnaire is given in Appendix A-1. In order to evaluate the application, a number of statements, or sub-criteria, were provided for each of the criteria generated by the researcher in Chapter 5 – see Table 5.3. Learners were required to indicate to what extent they agreed with these, using a five-point Likert rating scale (strongly agree to strongly disagree). However, since one of the main objectives was to identify usability problems, space was provided at the end of each criterion/heuristic (these two words are used interchangeably) for open-ended responses, where they could describe specific problem/s they identified in relation to that criterion. In the covering letter to learners, Appendix A-2, and in the questionnaire itself, it was emphasised to the learners that this was the main aim of the exercise.

Since the criteria in Table 5.3 are so general, learners at this academic level would probably not fully understand all the associated terminology. The set of statements given under each criterion elaborated its meaning, so as to support and motivate learners in giving responses. For example, the first criterion is ‘Visibility of system status’. To provide expanded meaning, learners were given statements such as:

- ‘The system keeps me informed through feedback about what is going on’; and
- ‘I get the feedback within reasonable time’.

After going through all the statements for a particular criterion and hopefully understanding its meaning, it was envisaged that learners could freely express their opinions in the open-ended sections by describing specific violations (problems) encountered with relation to that criterion.

In the concluding section of the questionnaire, learners were asked to evaluate the system in terms of overall usability and support for learning. This was followed by a section where participants could identify the most critical problems in the application and a section where they could express overall impressions and make any further comments.

Gillham (2000b:38) recommends that the title and organisation of a questionnaire should make it clear to the respondents what the investigation is to accomplish. However, a supplementary covering letter can be used to make it even more explicit. Such a letter was designed and is given as Appendix A-2. It introduced the researcher, explained the aim of the questionnaire, and gave detailed directions on how to complete it. A clause was included guaranteeing the confidentiality of the information provided. In addition to the covering letter, a consent form, Appendix A-3, was designed for respondents to indicate their agreement to participate in the evaluation exercise. This is recommended for ethical reasons, as outlined in Section 4.8.1.1.

Once all the documentation for the questionnaire was ready, a pilot study was conducted. This is discussed in the next section.

7.2.2 Pilot study

As stated in Section 4.8.2, questionnaires should be prepared, reviewed and tested with a small sample of users before carrying out a survey (Shneiderman & Plaisant, 2005:151). This view is supported by Olivier (1999:100) and Gillham (2000b:42), who recommend that a pilot study should be done to avoid problems such as the misunderstanding of instructions by respondents or the situation where respondents do understand the questions/instructions but do not have information to answer them. In a study to determine the usability of a library search system, Peng et al (2004:42) carried out a pilot study with ten users out of a set of 100 participants in order to discover inadequacies in the design of the questionnaire.

In this study, a pilot study was conducted with five learners and was found to be very useful. Apart from problems such as those mentioned in the previous paragraph, learners commented on issues such as the length of the questionnaire. Some suggested that it should be reduced in order not to tire the respondents. Using feedback from this pilot study and observation by the researcher during the exercise, a final questionnaire was compiled and used in the actual evaluation. This is discussed in the next section.

7.2.3 Actual evaluation

Out of a possible 80 learners, **61** participated in the evaluation of the Information Systems 3 web-based learning application, Info3Net, which was introduced in Chapter 6. The evaluation exercise was carried out during times when learners had free periods. Although learners were informed about the evaluation in advance, participation was optional and some chose not to participate. Participants were provided with the covering letter, consent form and actual questionnaire.

After going through the first two documents, they logged on to the site of the application and evaluated it. They were already familiar with Info3Net because they had been using it during their studies, as indicated in Section 6.5. Now they were required to evaluate it in its entirety and identify usability problems they had encountered at any time while using it. However they were asked to do two specific representative tasks to refresh their minds. They were asked to do a short reading of part of the content, which was followed by a five-minute test based on this and their general knowledge on the topic. These scenarios, in addition to the general site features such as its structure, became the specific focus of the evaluation, as they completed the questionnaire, although reference could also be made to problems in tasks done previously and, in fact, was welcome. Because learners constantly referred to the site as they evaluated it, it took them an hour to one-and-a-half hours to perform the evaluation. The results of this evaluation are discussed in Section 7.2.5.

The researcher studied their responses, and conducted a focus group interview with a group of learners as a follow-up process to clarify and expand some of the issues raised in responses to the questionnaire. The interview is discussed in the next section.

7.2.4 Focus group interview

As recommended in Section 4.8.1.4, a focus group interview was conducted with a representative sample of learners drawn from respondents in the questionnaire survey. This was done three days after the survey. The present researcher (i.e. the author of this dissertation) served as facilitator by asking simple questions and coordinating the responses from the group in order to distinguish the nature of the comments from each different individual. The aim of the exercise was to evaluate the system by expounding some of the problems identified in the questionnaire survey and possibly to identify more, as discussed in Section 4.8.1.4.

Since it is recommended that six to twelve people (Lewis, 1999; Maughan, 2003:107) form a focus group, eight learners were asked to participate. The exercise took about one-and-a-half hours. Several issues were clarified by the learners and more new problems emerged, which are discussed in Section 7.2.5.1.

7.2.5 Survey results

The background information given by the participants corresponded with the user profile in Section 6.5.1. They had all used computers for at least two years and could be described as expert computer users in relation to the environment in which the application was used. Apart from one, it was their first exposure to a web-based e-learning application.

7.2.5.1 Number and nature of problems identified

In the process of compiling problems, duplicate problems (which are instances of a generic kind of problem but occurring in different parts of the system) should be eliminated and listed as one unique problem (Lindgaard, 2004). This approach was followed during the evaluation.

The learners identified a total of **64** unique problems (listed in Appendix A-5). This subsection explains how these 64 problems were compiled and then integrated to a final set of 55 problems.

Eight 'learning-experience' problems were immediately excluded – problems relating to the five heuristics that were not used in the HE (see Sections 7.2.5.3 and 7.3.1). This was done to facilitate subsequent comparison of the results of the learner survey and of the HE by experts.

As stated in Section 7.2.1, the investigation of each criterion in the questionnaire (Appendix A-1) concluded with a space for open-ended responses where learners could mention problems they had experienced with relation to that criterion. The first **58** unique problems were identified from the problems described in these sections.

There were 110 statements in the questionnaires (shown in Appendix A-1). These statements were phrased in a positive, rather than a negative form, as illustrated by the two examples in

Section 7.2.1. Appendix A-4 summarises the ratings of the data collected from participants. The last column of the table in the appendix shows the average rating of each statement. On a Likert scale of 1 to 5 (strongly agree, agree, maybe, disagree, strongly disagree), the mean of these average ratings is 2.3 and the standard deviation is only 0.4. This means that most learners tended to agree with the statements given. This is further confirmed by the fact that in 92 statements (84%) out of the total 110, the average rating was less than or equal to 2.5, indicating a generally positive impression of Info3Net.

Using Appendix A-4, statements with an average rating of more than 2.5 were analysed so that if a statement was rated highly (indicating disagreement with the statement) and was not related to any of the 58 problems identified in the open-ended sections of the questionnaire, then it would be considered as an additional usability problem. **One** problem (Problem number 9.2 in Appendix A-5) was identified in this manner, raising the number of problems from 58 to **59**.

During the focus group discussion, issues were clarified and new usability problems were identified. For example, some learners had stated that the background colour was not consistent. During the discussion they gave more specific responses such as “Background colour for the Home Page is blue, but that of the Calendar is white” which clarified their claims. **Five** new usability problems (Problems 9.3, 11.8, 11.9, 18.7 & 18.8 in Appendix A-5) were identified in the focus group exercise and were incorporated into the students’ list of problems. This raised the number of problems from 59 to **64**, forming a set of 64 unique problems in Info3Net as identified by learners. These problems are listed in Appendix A-5, as mentioned already.

To consolidate the list, it was necessary to combine some that were closely related. For example, the following three problems (Problems 11.1, 11.2 and 11.9 in Appendix A-5):

- ‘There is no Forward/Next button’,
- ‘There is no Back button so it is difficult to link back to the previous page’, and
- ‘There should be Forward and Back buttons within the site apart from those on the browser’

were combined to form Problem 11.1 in Table 7.1:

  - ‘Apart from the buttons provided by the browser, there should be a Back/Previous and Forward/Next button within the application’.

A further reason for such integration was to rephrase the problems slightly so as to make them closely analogous to those identified by the expert evaluators. A similar procedure was undertaken with problems identified by the experts, which will be discussed in Section 7.3.6.1. This condensed it to a final list of **55** learners’ problems, shown in Table 7.1, where the *f* (for frequency) column represents the number of students who identified the problem.

Although **61** learners were involved in the evaluation exercise, most of the problems were identified by less than ten learners, as indicated in the *f* column. However, there are four statements where the frequency is higher than ten, indicating areas of greater concern. Three of these four (Statements 3.1, 3.2 & 3.3) relate to Heuristic 3 (User control and freedom) indicating that learners had problems controlling the system due to lack of Undo and Redo buttons, lack of a system exit button, and slow response by the system. The fourth statement (Statement 11.1) in this category, i.e. ‘Lack of Back and Forward buttons’, is closely related to the other three. This further confirms that a number of learners felt that they could not control the system due to its lack of critical navigational buttons. The fact that most problems were identified by just a few learners indicates that most of the learners did not experience many problems in using Info3Net.

The number of problems identified for each of the fifteen heuristics in Table 7.1, ranges from two to six. It is difficult to use this to determine the exact degree to which that particular heuristic was violated, but an indication of the extent can be obtained by considering the number of learners who identified problems relating to that heuristic. Examples are:

- Heuristic 7 (Flexibility and efficiency of use) has six problems, identified by a total frequency of only 22 (7 + 5 + 4 + 3 + 2 +1).
- Heuristic 3 (User control and freedom) has five problems (fewer than Heuristic 7 above) but a total frequency of 50 (16 + 13 +12 + 7 + 2), showing that more learners identified them.

Table 7.1: The final set of 55 problems identified by the learners

	Problem	
	Category 1: General interface design heuristics	***f***
1	**Visibility of system status**	
	1.1 When doing a quiz/test, if an answer has already been saved and then if one changes his/her mind and selects another answer and clicks the Save Answer button, there should be feedback by the system to confirm that the later answer is the one accepted.	1
	1.2 The time allocated to do a quiz/test should be known before, instead of after the user clicks on the button to start the test.	1
2	**Match between the system and the real world i.e. match between designer model and user model**	
	2.1 Symbols are not meaningful.	8
	2.2 Some terminologies are unfamiliar.	5
	2.3 Calendar should be called a Diary.	1
3	**User control and freedom**	
	3.1 There are no facilities for Undo and Redo.	16
	3.2 The system is slow to respond.	13
	3.3 There is no system exit button.	12
	3.4 When doing a quiz/test, if the test is submitted before the time expires, one should have a chance to change answers within the time limit.	7
	3.5 It is not easy to print site content. For example, there is no 'Print version' of the notes found in the hyperlinks in the Table of Contents.	2
4	**Consistency and adherence to standards**	
	4.1 Same symbols/icons represent different things.	7
	4.2 Background colour is white on some pages and blue on others.	6
	4.3 In order to be consistent, the format for the self test should be the same as that of the quiz/test.	2

	4.4 All pages should have a title, but the Introduction page does not.	1
	4.5 On the Course Material page, the size and layout of the 'Databases' icon should be consistent with the other icons by not having a different size and shape.	1
5	**Error prevention, specifically prevention of peripheral usability-related errors**	
	5.1 The system does not always give error messages to prevent errors from occurring.	3
	5.2 When doing a quiz/test, the system should inform the user immediately he/she tries to move away from a question, that the answer selected is not saved. Instead, the user is informed at the end of the quiz/test.	3
	5.3 Whatever is entered into the system is accepted. There are no ways to avoid erroneous/meaningless entries.	2
6	**Recognition rather than recall**	
	6.1 Instructions on how to perform tasks should be visible, for example, they should be bold and/or in large font sizes. Examples: 1. On the View Results page for multiple choice questions for quizzes/tests, the row in which the correct answer is located should be bold so as to be easily recognisable. 2. Some links, WebCT™ default links, such as Resume Course, are difficult to recognise since they are labelled in small fonts.	3
	6.2 There is no obvious relationship between controls and their actions.	1
7	**Flexibility and efficiency of use**	
	7.1 It is not easy to navigate the system using the keyboard only.	7
	7.2 The system cannot be customised.	5
	7.3 There are no shortcuts provided.	4
	7.4 The system is not flexible "you do what is exactly required and leave it that way".	3
	7.5 The system does not cater for novice users.	2
	7.6 It is not easy to use the Help System. For example, the structure of the WebCT™ Help System is confusing.	1
8	**Authenticity and minimalism in design**	
	8.1 Notices on the Notice Board should show the dates when they were posted.	10
	8.2 When starting a quiz /test, there is too much info in one window.	2

	8.3 The use of a three-window design for the Table of Contents makes it difficult to read the content.	1
	8.4 Instead of saving each answer one-by-one, there should be one Save Answers button for the entire quiz/test, to minimise time loss.	1
9	**Recognition, diagnosis, and recovery from errors**	
	9.1 The error messages given are not helpful, for they do not provide any instructions to fix errors.	7
	9.2 If a typed command (data) results in an error message, one has got to retype the entire command instead of repairing the faulty part.	3
	9.3 When the wrong password is entered for a quiz/test, the error message should be in a text box instead of appearing on the screen where it is entered.	1
10	**Help and documentation**	
	10.1 It is not easy to search for information on the site.	3
	10.2 The Help System is not appropriate for the user, since it refers to issues more relevant to the designer than to the learner.	2
	10.3 There is no FAQ section.	1
	10.4 There is no section on how to use the site.	1
	Category 2: Website-specific design (educational websites) heuristics	***f***
11	**Simplicity of site navigation, organisation and structure**	
	11.1 Apart from the buttons provided by the browser, there should be a Back/Previous and Forward/Next button within the application.	19
	11.2 There should be colour differences between the visited, non-visited and current site links. For example, the colours of the links should be consistent with Web conventions, i.e. non-visited links blue and visited ones green or purple, and the Course Menu should show where the user is.	3
	11.3 On the Home page, the options should be arranged in a more natural order.	2
	11.4 There should be links to sections inside the same page/document to minimise scrolling.	1
	11.5 The link to the library under Useful Links should link to the relevant materials in the library, but not to the library's search section.	1

	Category 3: Learner-centred instructional design heuristics	***f***
13	**Clarity of goals, objectives and outcomes**	
	13.1 Calendar information is not sufficient.	6
	13.2 Course goals are not clear.	3
	13.3 Links on main page should be accompanied by brief explanations of what is found in the sections to which they are linked.	2
14	**Collaborative learning**	
	14.1 Although facilities exist for learner-learner and learner-teacher interactions, there are no procedures in place to encourage their use.	3
	14.2 There are no facilities for synchronous communication such as video conferencing.	1
18	**Feedback, guidance and assessment**	
	18.1 The guidance provided via the system about the learners' activities is limited. For example, diagrams and pictures should be used to illustrate learning concepts.	4
	18.2 Glossary is not sufficient. More terms/phrases need to be defined.	3
	18.3 Class lecture slides/notes, and quiz/test and assignment solutions should be available on the site.	3
	18.4 In Question 1 of the quiz/test done during the evaluation, the word 'metadata' is shown as the correct answer but 'Metadata' is marked wrong. However, learners were not informed that the system is case sensitive.	2
	18.5 The feedback provided via the system about the learners' activities (such as tests and assignments) is limited.	2
	18.6 There should be links to previous years' learning material.	1
20	**Motivation, creativity and active learning**	
	20.1 There are inadequate activities to attract learners to the site.	3
	20.2 More content is required to encourage learners to compare, analyse or classify information so as to promote active learning and intuition	2

Table 7.1: The final set of 55 problems identified by the learners

Further analysis of the nature of the problems identified by learners can be done using the data in Appendix A-4 (Questionnaire rating summary). Table 7.2 lists the statements with the highest average ratings (average ratings of 2.9 and more).

	Statement	Average rating
1	When I make a mistake I can choose to exit (close) the system, using a clearly marked Emergency Exit button.	3.1
2	I find it easy to search for required help.	3.1
3	There is an option to use the keyboard alone to perform tasks.	3.0
4	The system is flexible enough to enable users to adjust settings to suit themselves, i.e. customise the system.	3.0
5	I find the Help facilities – such as online help and the Glossary – useful.	3.0
6	Each message gives a procedure to fix the error.	2.9
7	The procedure to fix the error is specific, quick and efficient.	2.9
8	The site provides for easy reversal of action where possible, for example, by providing both Undo and Redo.	2.9

Table 7.2: Statements from the questionnaire with the highest average ratings

These high ratings indicate that, in general, learners disagreed with these statements, thus indicating problem areas. Of the eight statements, two of them (Statements 1 and 8 in Table 7.2) indicate problems with the level of user control of the system, due to the lack of certain navigation buttons, such as an Exit button. Statements 2, 5, 6 and 7 (in Table 7.2) show that when learners made errors, they found it difficult to recover, especially since Info3Net does not have a useful Help System. Statements 3 and 4 indicate that it is difficult for users to customise Info3Net or to manipulate it using a variety of interactive devices.

Chapters 2 to 4 overviewed theoretical concepts that were incorporated into the evaluation criteria in Chapter 5. Some of the criteria have their roots in tenets of constructivist learning. Others emphasise the value of interactivity, flexibility, and feedback. Info3Net, on the other hand, was developed in the WebCT™ environment and does not readily support all these features, as shown by the problems in the previous paragraph.

Confirmation of the lack of such features comes from the learners' identification of the following problems:

- The system cannot be customised.
- The system is not flexible “you do what is exactly required and leave it that way”.
- The error messages given are not helpful, for they do not provide any instructions to fix errors.
- The guidance provided via the system about the learners’ activities is limited. For example, diagrams and pictures should be used to illustrate learning concepts.
- There are inadequate activities to attract learners to the site.

These are problem areas that should be addressed in a future upgrade of Info3Net.

It should be noted that the learners’ questionnaire was aimed primarily not at assessing Info3Net's level of conformance to each of the heuristics, but rather at identifying the problems. The statements given for each criterion/heuristic (see Appendix A-1) were merely there to help learners grasp the meaning of a particular criterion, as stated in Section 7.2.1, and not to define the criterion exhaustively. Consequently, the average ratings for each statement under a given criterion cannot be used as a precise measurement of that particular criterion, but they do serve as pointers to specific problem areas in the application.

Section 7.3.6.2 combines the problems identified by learners with those identified by experts in a final consolidated list. Further analysis of the number of problems for each criterion, the number of problems in each category (General, Web and Educational), and discussion of the severity of each problem, is undertaken in Section 7.4.

7.2.5.2 Overall assessment of usability and support for learning

In addition to identifying the type of problems discussed in the previous section, learners were asked to assess the overall usability of Info3Net and its support for learning (see ‘Conclusion’ section of Appendix A-1). Table 7.3 shows the percentage of learners who selected a particular option (strongly agree to strongly disagree) for each statement or question relating to usability and learning value. Figure 7.1 shows the corresponding graph.

The data which forms the basis of Table 7.3, and the actual number of learners who selected a particular option, are given in the 'Conclusion Section' of Appendix A-4.

#	**Statement/Question (Usability Factor)**	***Strongly agree (Likert 1) (%)***	***Agree (2) (%)***	***Maybe (3) (%)***	***Disagree (4) (%)***	***Strongly disagree (5) (%)***	***Average rating (1-5)***
a	I found it easy to use the system.	38	52	8	2	0	1.7
b	The system is fast to work with.	23	51	11	13	2	2.2
c	The system performed tasks properly.	20	69	10	2	0	1.9
d	Once I learnt how to use the system it was easy to use it the next time.	33	62	5	0	0	1.7
e	I was satisfied with the system.	20	59	16	5	0	2.1
	Average % for **a** *to* **e** *(usability)*	**26.6**	**58.7**	**10.2**	**4.2**	**0.3**	**1.9**
		V. Good	***Good***	***Adequate***	***Poor***	***V. Poor***	
f	How well did the site work as a supplement to class instruction?	23	61	13	3	0	2.0
		Site	***Class***	***Both***			
g	I would rather learn using	10	5	85			
		V. Good	***Good***	***Adequate***	***Poor***	***V. Poor***	
h	What is your overall rating of this site?	21	70	5	3	0	1.9

Table 7.3: Percentage (%) of students who selected a given option for each statement or question

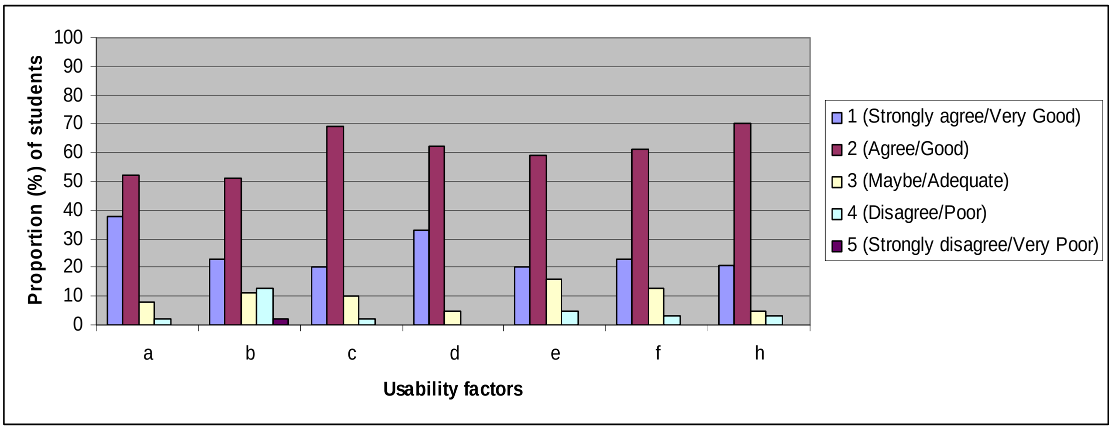

Figure 7.1: Students' rating of Info3Net

The responses for statements **a** to **e** were for assessment of the factors associated with usability, as discussed in Section 4.3.3, namely:

a) Ease of use;
b) Efficiency;
c) Effectiveness;
d) Easy to remember; and
e) Satisfaction.

As can be seen from the graph in Figure 7.1, most learners rated the site highly in terms of its usability (Strongly agree or Agree). Taking these five factors (Statements **a** to **e**), Table 7.3 shows that the average percentages for 'Strongly agree' and 'Agree' are 26.6% and 58.7% respectively. This means that in total 85.3% (26.6 + 58.7) of the score falls in these two categories, indicating a high rating for usability of Info3Net.

Question **f** investigates the operation of Info3Net as a supplement to class instruction, and here 84% (23 + 61) responded favourably (Very good or Good). These percentages correspond well with the learners' overall rating of the site (Question **h**) where 91% (21 + 70) rated it as Very good or Good. Finally, 85% preferred to use both class and site for learning (Question **g**), compared with 10% who would prefer the site only and 5% who prefer class instructions only.

In general, the statistics in the previous paragraph show that learners were positive regarding the usability of the site and its support for learning. This is confirmed further by some of their open-ended comments, for example:

- "The site is easy to use and has straightforward links".
- "The interface is easy to use".
- "I like the newness in learning – different learning styles. You feel like studying – it inspires you. You are like your own online tutor".
- "Overall the whole system is good. It does help in testing your knowledge and finding summarised notes and scope".
- "The site is well organised and easy to navigate".
- "I like the site layout".
- "The site was fun to work with and I think it should be used more often in the future".
- "It was really fantastic to use the site. Features are connected to each other".
- "The site helps me to improve my skills and evaluate my learning abilities".
- "We should use WebCT™ for all other subjects".

7.2.5.3 Problems identified by learners only

As indicated in Section 7.2.5.1 and discussed further in Section 7.3.1, there were five evaluation criteria in the learner-evaluation that were not considered by the expert evaluators, because they relate specifically to the learning experience of individual learners. The problems discussed in the previous two subsections (Sections 7.2.5.1 and 7.2.5.2) exclude the issues identified by learners with respect to those five criteria. However, Table 7.4 shows the **eight** problems identified by learners in this regard. The format is the same as that of Table 7.1 with the *f* column representing the number of learners who identified the problem.

Only eight problems were identified for the five criteria, resulting in a ratio of 1.6 problems per criterion. This is low compared to the 58 problems identified for the other fifteen criteria, giving a ratio of 3.9 problems per criterion. A probable reason is that the learners lack strong individual views on how best to learn, or possibly because they were not in a position to assess the appropriativeness of the learning content. For Heuristic 17 (Cognitive error recognition, diagnosis and recovery), related to cognition, no problems were identified at all.

	Problem	
	Category 2: Website-specific design (educational websites) heuristics	***f***
12	**Relevance of site content for learning**	
	12.1 Some content is unclear or confusing.	1
	12.2 Site does not show which material is copyrighted and which is not.	1
	Category 3: Learner-centred instructional design heuristics	***f***
15	**Appropriateness of level of learner control**	
	15.1 Site should have links to useful Internet sites, apart from the Intranet links it has, so that learners can easily access other learning material.	7
	15.2 One does not feel any sense of ownership of the system.	1
16	**Support for personally significant approaches to learning**	
	16.1 There should be puzzles, crosswords and/or online practical exercises to do individually or in teams.	4
	16.2 The site should be more integrated with other mediums of instructions to support learning.	2
17	**Cognitive error recognition, diagnosis and recovery**	
	17.1 —	
19	**Meaningful context**	
	19.1 Some symbols do not make sense in a learning situation.	2
	19.2 Some tasks are not related to real-world tasks.	3

Table 7.4: The eight problems for the criteria presented to learners only

Although only a few problems were identified using the five heuristics, and by a small number of learners, the problems relate to important issues that should not be ignored. For example, from Problem 19.2 one can infer that learning tasks should be related to authentic real-world situations, and from Problems 15.1 and 16.2 one can infer that learners should be provided with multiple forms of knowledge representation. These recommendations are in line with the constructivist approach to learning discussed in Section 2.2.3.1.

Further analysis of the learners' results is conducted in Section 7.4 where they are compared with those of the expert evaluators.

7.3 Heuristic Evaluations by Experts

The heuristic evaluation (HE) methodology is described in Section 4.9.1. The approach used in this study is based on the methodology used by Nielsen (1994:38-49) and can be subdivided into the following phases:

- Identifying and defining the heuristics to be used;
- Selection of evaluators;
- Briefing the evaluators;
- Actual evaluation; and
- Severity rating.

These phases are briefly described in Sections 7.3.1 to 7.3.5 respectively, followed by results and analysis of the HE in 7.3.6. HE is often conducted in formative evaluation during development stages. But in this study, it is done on an operational application, so as to compare the results of evaluation by two different methods on exactly the same system.

As will be described in Section 7.3.5, the problems identified by learners and experts were combined for the subsequent severity rating process (Appendix C-1 is a list of the learners' problems integrated with those identified by the expert evaluators, and then used for severity rating of the problems).

7.3.1 Identifying and defining the heuristics to be used

The criteria in Table 5.3 (Heuristic evaluation criteria for web-based learning) were used as the heuristics for this evaluation. Some, however, for example, ‘Support for personally significant approaches to learning’, were excluded since they involve either assessment of subject content or individual learners’ satisfaction with the system in terms of its usability or learning. These can be assessed best by learners, as discussed in Sections 7.2.5.1 and Sections 7.2.5.3. Therefore, Criteria 12, 15, 16, 17 and 19 were omitted. Appendix B-1 gives the fifteen heuristics used for the evaluation, each followed by a few statements that describe it.

7.3.2 Selection of evaluators

In the selection of evaluators, factors to be considered are the number of evaluators and their respective backgrounds. In Section 4.9.1.1, it is recommended that three to five evaluators should be used in heuristic evaluation. The higher the number of evaluators, higher would be the proportion of problems found. However, the actual number depends on cost-benefit analysis, which is highest when three or four evaluators are employed (Nielsen, 1994:33). Despite this, the debate continues on the optimal number of evaluators. For example, in a study to determine the usability of a Web portal for staff and students of a university department, Avouris et al (2003:223) used eleven expert evaluators. However, Karoulis and Pombortsis (2003:97) argue that two to three evaluators who are experts in both the domain area and Human Computer Interaction (HCI) – referred to as ‘double experts’ – will point out the same number of usability problems as three to five ‘single experts’. Furthermore, in a heuristic evaluation of an educational multimedia application, by Albion (1999), a group of four evaluators was selected, comprising experts with expertise in user interface design, instructional or educational design, and teaching. The last approach was used in this case study. Four expert evaluators with expertise in user interface design, instructional or educational design, and teaching were invited to participate and agreed to do so.

Table 7.5 shows the profiles of the four expert evaluators selected. All of them are academics who lecture, perform postgraduate supervision, and conduct research at universities.

	Evaluator 1	**Evaluator 2**	**Evaluator 3**	**Evaluator 4**
Highest qualifications	MEd & PhD	MCom (IS)	MEd & MSc(IS)	MEd & DSc(Ed)
Professional role **Duties/courses taught (relevant to this study)**	Prof. in Dept. of Education. Lectures ICT, Computer Literacy & Psychology of Education	Senior lecturer in Dept of IS. Course manager for IS honours. Lectures HCI at honours level and Database Design at 3rd year level.	Prof. in Dept. of IS. Course manager for IS masters. Lectures HCI at honours level and Database Design at 3rd year level.	Senior lecturer in Dept. of IT. Lectures Research Skills at B.Tech (4th year IT) level and IT Internet Programming at 2nd year level

Table 7.5: Profiles of the expert evaluators

Evaluator 1 is a professor in a Department of Education, teaching Information and Communication Technology (ICT), Computer Literacy and Psychology of Education. Evaluator 2 is a senior lecturer in a Department of Information Systems (IS) and is course manager for Information Systems Honours. She teaches Human Computer Interaction (HCI) at honours level and is conversant with the Database Design subject matter presented to the learners in this study. Evaluator 3 is a professor in a Department of IS with masters degrees in both Education and Information Systems. She is course manager for the Masters Information Systems. Like the previous evaluator, she lectures an HCI course at honours level and Database Design on the same level as presented to the learners in this study. Evaluator 4 is a senior lecturer in an Information Technology Department and has a DSc in IT education. She, like Evaluator 1, has no HCI experience. Evaluators 1 and 2 are employed in the same university, but in different departments, while the others are in different universities. The evaluators thus represent three different tertiary institutions.

7.3.3 Briefing the evaluators

Evaluators should be briefed about the HE method as used in the current study, the domain of use of the system being evaluated, and a scenario to work through while using the system (Levi & Conrad, 1996:54; Nielsen, 1994:39).

A set of documents addressing these three aspects was compiled and given to each evaluator. They include the following:

- **Phases** (Appendix B-2): This provides overall guidelines to the whole evaluation process up to the severity rating phase. It describes the stages of the process, documents to be read and estimated time to perform the evaluation.
- **System and user profile** (Appendix B-3): This gives a general background to the system and the learners, and sets out how the system was used by the learners. Since the users are learners, it was thought necessary to brief the evaluators regarding the learners' level of expertise with the system.
- **Procedure** (Appendix B-4): This describes the procedure to follow in order to conduct the HE. It includes details of how to login to the website, the scenarios to perform, how to do the actual evaluation, and how to compile the report of the usability problems.

In addition to these documents, a consent form for evaluators was included (see Appendix B-5). Evaluators were requested to read all the documents and to familiarise themselves with the heuristics (Appendix B-1) before doing the actual evaluation, which is discussed in the next section.

7.3.4 Actual evaluation

As recommended by Nielsen (1994:40), each of the four expert evaluators conducted his/her evaluation independently from the others. The five documents described in Sections 7.3.1 and 7.3.3 and given in Appendix B were sent to them via e-mail. The two scenarios the experts were asked to perform, were the same as those done by the learners in their evaluation of the application. Apart from these specified tasks, the expert evaluators were asked to evaluate other general features of the application, just as the learners did.

Evaluators were given a period of three weeks in which to find a two-hour period during which they could access the Internet in order to evaluate the application. Due to time constraints over a particularly busy academic period, only one of the four managed to do it within the envisaged window period. The time taken was two hours. One of the initial evaluators was unable to participate and was replaced by another one, Evaluator 4. Because the main obstacle was lack of time, it was decided, following discussion with the rest of the evaluators, that the researcher/author of this dissertation should be available during the evaluation process as an observer to answer queries. This approach enables the evaluator to concentrate on identifying and pointing out the usability problems while the observer notes them down. This speeds up the evaluation (Nielsen, 1994:40) and the designer/researcher can clarify issues as they arise (Levi & Conrad, 1996:54). With the option of having the observer physically present, the three remaining experts finished the evaluation within the following ten days and, with support from the observer, were able to complete it in approximately half the time take by the first evaluator.

One of the issues about heuristics is that a single problem may violate more than one heuristic (Lindgaard, 2004). For example, if most buttons on an interface are the same size and shape, but one differs, then the different one violates both the consistency and visibility heuristics. In such cases, a single problem was recorded under the heuristic that seemed to be violated the most.

Once all the evaluations had been done, the severity rating of the usability problems identified, followed. This process is described in the next section.

7.3.5 Severity rating procedure

This section sets out the procedure used for severity rating, while the actual results are presented in Section 7.4.3.

As discussed in Section 4.9.1.5, severity rating, i.e. assigning relative severities to individual problems, is performed as part of the heuristic evaluation process to determine the degree of seriousness of the problem. It was stated in Section 4.9.1.5 that expert evaluators can either rate the severity of each problem during the HE process or at a later stage when problems from all the evaluators have been aggregated. However, it was pointed out, in the same section, that the latter approach is advantageous (Albion, 1999; Levi & Conrad, 1996:55; Lindgaard, 2004; Nielsen, 1994:48) and this was therefore the method used in this case study. Each evaluator has a chance to rate each problem identified. The scores from the different evaluators are then averaged to determine the final severity of a problem. This rich process would not be possible if each evaluator rated his/her problems during the evaluation, since each usually identifies a subset, but not all, of the problems. It was established in a study by Nielsen (1994:49) that this approach is reliable, since any given evaluator's severity rating of a usability problem was independent of whether that particular evaluator had identified the problem or not.

Table 7.6 shows the 5-point rating scale (Pierotti, 1996) used to assign severity to the problems and a further option to indicate a non-problem. The scale is closely related to the one used in Table 4.5, except that the first option in Table 4.5:

- '**0 –** I do not agree that this is a usability problem at all' is eliminated and replaced by:
- '**N –** Not Applicable: I don't consider this to be a problem',

Thus the letter 'N' is entered, instead of assigning a non-problem a weight of zero. This scale is similar to that used by Albion (1999) in an HE of educational multimedia, where 1 is poor and 5 is excellent, with an additional rating of NA for 'Not Applicable'.

The combined list of problems from the four evaluators (58 problems, to be shown in Table 7.7) was merged with the problems identified by the learners (55 problems, shown in Table 7.1) to make a single set of all the identified problems. This was sent to the evaluators for severity rating. The problems were categorised according to the criterion they violated. To provide more information, each problem was accompanied by a weighting indicating how many experts and how many students had identified that problem. The problems for each criterion were grouped in descending order, according to the number of experts by whom it had been identified. Appendix C-1 shows the severity rating form.

Description	Score
Cosmetic problem: will not affect the use of the system. Fix it if possible.	1
Minor problem: users can easily work around the problem. Fixing this should be given a low priority.	2
Medium problem: users are likely to encounter this problem but will quickly adapt to it. Fixing this should be given medium priority.	3
Major problem: users will find this problem difficult but may be able to find workarounds. It is important to fix this problem. Fixing it should be given a high priority.	4
Catastrophic problem: users will be unable to do their work because of this problem. Fixing it is mandatory.	5
Not Applicable: I don't consider this to be a problem.	N

Table 7.6: Five-point rating scale for severity of usability problems (Pierotti, 1996)

All the expert evaluators e-mailed back the completed form within three days of receiving it. The exercise took them an average of ten minutes. The results of the severity rating exercise are in Appendix C-2. They will be discussed in Section 7.4.3.

Expert evaluators were not paid for their participation in either the evaluation of the application or severity rating of the problems. However, a token gift was given to them as an expression of gratitude.

7.3.6 Heuristic evaluation results

7.3.6.1 Problems identified by the individual evaluators

As described in Section 7.3.2, four experts participated in the heuristic evaluation of the e-learning application for this study. A list of **77** unique problems was initially identified by these experts (given in Appendix B-6). However, as discussed and explained in Section 7.2.5.1 with relation to the learners' problems, problems that were closely related were similarly consolidated and combined. This resulted in a final list of **58** problems emerging from the expert evaluators. This list is shown in Table 7.7. The *Eval* column indicates which expert evaluator/s identified the problems and *f* (for frequency) indicates the number of experts who recognised it. For example, Problem 2.1 was identified by Evaluators 3 and 4, giving a frequency of 2. Table 7.8, following Table 7.7, indicates the number of problems identified by each evaluator for each heuristic.

Table 7.7: The final set of 58 problems identified by expert evaluators

	Problem		
	Category 1: General interface design heuristics	**Eval**	***f***
1	**Visibility of system status**		
	1.1 When doing a quiz/test, if an answer has already been saved and then if one changes his/her mind and selects another answer and clicks the Save Answer button, there should be feedback by the system to confirm that the later answer is the one accepted.	3	1
	1.2 When submitting a quiz/test, the following message is given in a dialog box "All questions have been answered and all answers have been saved. Do you want to proceed?". It is accompanied by an OK and a Cancel button. In this case the cancel option is confusing, since it is not clear whether it refers to the cancellation of this step or of the whole quiz/test.	3	1
	1.3 When starting a quiz/test, the only button on this page is 'Begin Quiz'. It is surprising that, when the Enter key is used, the system displays the same page, still with the 'Begin Quiz' button, with the exception of the textbox and the instructions for entering the password.	2	1
	1.4 In rare circumstances, when some of the links on the Course Menu (site index) are clicked, the message "WebCT™ has not been configured to run with framesets" appears and the Course Menu disappears. This is a surprise action.	4	1
2	**Match between the system and the real world i.e. match between designer model and user model**		
	2.1 Some labels/names should be changed if they are to be meaningful. For example, when notes are taken for the first time, the button for saving them should not be labelled 'Update', and the Calendar object should be called a Diary.	3,4	2

	2.2 Symbols such as the icons used on the Home Page are not meaningful.	3	1
	2.3 Some terminologies are unfamiliar, for example, under Discussions, the status of a topic could be 'Public, Unlocked'. Learners (users) do not understand this. Similarly, the phrases 'Content module' and 'Content page', used by the Help System are unfamiliar to users.	3	1
	2.4 The options, such as 'Content module table of contents', given in the dropdown list on the Search page should match those on the Course Menu options.	3	1
	2.5 On the Communicate page, the options should be arranged in alphabetic order i.e. Discussion, Mail and Notice Board, instead of Discussion, Notice Board and Mail, as is the case now.	2	1
	2.6 The visual layout of the Course Menu should be more natural in that items at the same site level should have the same alignment. For example, those on the Home Page (level 1) should have the same alignment.	2	1
3	**User control and freedom**		
	3.1 It is not easy to print site content, such as the Learner Guide and Content Modules. For example, there is no 'Print version' of the notes found in the hyperlinks in the Table of Contents.	1,2,3	3
	3.2 There are no facilities for Undo and Redo.	2,3	2
	3.3 Sometimes the system is slow to respond.	4	1
	3.4 There is no system exit button.	4	1
	3.5 There is no way to exit the Help System to the main system, apart from closing the Help window.	4	1
4	**Consistency and adherence to standards**		
	4.1 In order to be consistent, the format for the self test should be the same as that of the quiz/test. For example, a mark/grade should be allocated as is done with a quiz/test.	2,3,4	3
	4.2 Same symbols/icons represent different things. For example, on the Home Page the icon for Student Resources is the same as that for Assessment.	4	1
	4.3 There should be consistency in the spacing and size of items. For example, some of the spaces between the Leaner Guide sections are single and others double.	3	1
5	**Error prevention, specifically prevention of peripheral usability-related errors**		
	5.1 The system does not give error messages to prevent errors from occurring.	3	1

	5.2 In some cases, there are no ways to avoid erroneous/meaningless entries. For example, in Discussions, whatever is entered as a title or message is accepted.	3	1
6	**Recognition rather than recall**		
	6.1 It is sometimes difficult to recognise the relationship between different sections, between actions and their results or between controls and their actions. For example, in the Take Notes section, when the View All option is selected, it is difficult to know which notes relate to which section, and it is not easy to recognise that by clicking on the arrow next to the 'Course Menu' label the Course Menu window disappears or reappears.	1,2, 3,4	4
	6.2 Instructions on how to perform tasks should be visible; for example, they should be bold and/or in large font sizes.	2,3	2
	6.3 When starting a quiz/test, after entering the password, there should be an Enter button next to the textbox for the password, instead of the Begin Quiz button which is several line spaces down from the textbox.	2	1
	6.4 When there is a space in a fill-in-the-answer question in a quiz/test, it is not clear whether to insert the answer in that space or in the text box after the question.	3	1
	6.5 On the View Results page for quizzes/tests, 'Attempt: 1/1' is confusing since the '1/1' could be mistaken for a score.	3	1
7	**Flexibility and efficiency of use**		
	7.1 The system cannot be customised.	1,3,4	3
	7.2 There are no shortcuts provided.	3,4	2
	7.3 It is not easy to perform tasks using some of the facilities such as the Calendar, Discussions and Help System.	3,4	2
	7.4 The system is not flexible in its use.	4	1
	7.5 The system does not cater for different levels of users.	4	1
	7.6 When entering date/time values, in order to speed up data entry, the default values should be '00' instead of '--'. For example, if the user needs to enter the time as 13h00 in the Calendar, he/she should not be forced to select the '00' to replace the '--'.	2	1
8	**Authenticity and minimalism in design**		
	8.1 Notices on the Notice Board should show the dates when they were posted.	3	1

	8.2 When starting a quiz /test, there should be one window with instructions on how to do the test followed by another window for entering the password. This would be preferable to clustering all the information on one window.	2	1
	8.3 The use of a three-window design for the Table of Contents makes it difficult to read the content.	1	1
9	**Recognition, diagnosis, and recovery from errors**		
	9.1 The error messages given are not helpful, for they do not provide any instructions to fix errors.	3,4	2
10	**Help and documentation**		
	10.1 It is not easy to search for information on the site.	2	1
	10.2 The Help System is not appropriate for the user, since it refers to issues more relevant to the course designer (or educator) than to the learner.	3	1
	10.3 There is no obvious help given to show how to reduce the three-window design to a two- or one-window design.	1	1
	Category 2: Website-specific design (educational websites) heuristics	**Eval**	***f***
11	**Simplicity of site navigation, organisation and structure**		
	11.1 Site content is not arranged hierarchically, from general to specific.	2,3	2
	11.2 There should be links to sections inside the same page/document to minimise scrolling.	3,4	2
	11.3 The Back button should refer to the page that the user was on before the current one; for example, in the Help System the Back button should not refer to the previous section of the of the Help System but rather to the one visited before the current one.	3,4	2
	11.4 In order to improve readability, the Course Menu should be wider, and the spaces between its different sections should be larger than the spaces between items of the same sections.	2	1
	11.5 There should be lines between the different windows in the two- or three-window design.	2	1
	11.6 On the Course Menu, the Communicate option should be positioned last, so that there is space for it to grow its submenu as more information is subsequently added, for example, new notices.	2	1
	11.7 The Breadcrumbs of the site come out clearly when the links within the page are used for navigation, but do not come out when the Course Menu links are used.	2	1

	Category 3: Learner-centred instructional design heuristics	**Eval**	***f***
13	**Clarity of goals, objectives and outcomes**		
	13.1 Calendar information is not sufficient to assist the learner in determining what is to be done when.	3	1
	13.2 Course goals are not clear.	3	1
	13.3 Each link on the Home Page needs a brief description/indication, underneath it, of the information to be found by selecting it.	4	1
	13.4 The main course goals/objectives should be visible or immediately accessible from the Home Page.	4	1
14	**Collaborative learning**		
	14.1 Although facilities exist for learner-learner and learner-teacher interactions, there are no procedures in place to encourage their use.	3,4	2
18	**Feedback, guidance and assessment**		
	18.1 There is limited guidance to the learners as they perform tasks. For example, the explanation “The logical structure is visualized as a matrix composed of intersecting rows, one for each entity, and columns, one for each attribute”, should be supplemented with a graphical illustration (diagrams/pictures) of this relationship.	1,3,4	3
	18.2 The feedback provided via the system about the learners’ activities is limited and not obvious to the learners.	2,3,4	3
	18.3 Glossary is inadequate. More terms/phrases need to be defined.	2	1
	18.4 In Question 1 of the quiz/test the word ‘metadata’ is shown as the correct answer, but ‘mettadata’ and ‘Metadata’ are both marked wrong. However, learners were not informed that exact spelling is necessary or that the system is case sensitive.	1	1
	18.5 The way content is provided to learners is sometimes misleading, for example, when the question “what are keys?” is asked; the question is not answered but instead, examples are given of the different keys.	1	1
	18.6 In order to guide learners, database-specific jargon should be hyper-linked to the Glossary or to a section where terms are explained later in the text. For example, in the sentence “The relational database makes use of *controlled redundancy* to maintain *integrity* while linking related tables”, the italicised words should be hyper-linked to their meanings or definitions.	1	1

20	**Motivation, creativity and active learning**		
	20.1 There is no site content that encourages learners to compare, analyse or classify information so as to promote active learning or intuition.	2,4	2
	20.2 There are inadequate activities on the site to attract or engage learners.	3	1

Table 7.7: The final set of 58 problems identified by expert evaluators

Table 7.8 now summarises the number of problems identified by each evaluator for each heuristic.

Heuristic No.	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Total problems	By single expert
1	0	1	2	1	4	4
2	0	2	4	1	6	5
3	1	2	2	3	5	3
4	0	1	2	2	3	2
5	0	0	2	0	2	2
6	1	3	4	1	5	3
7	1	1	3	5	6	3
8	1	1	1	0	3	3
9	0	0	1	1	1	0
10	1	1	1	0	3	3
11	0	5	3	2	7	4
13	0	0	2	2	4	4
14	0	0	1	1	1	0
18	4	2	2	2	6	4
20	0	1	1	1	2	1
Total	**9**	**20**	**31**	**22**	**58**	**41**

Table 7.8: Number of problems identified by each evaluator for each heuristic

The *Total problems* column refers to the total number of problems identified by the four expert evaluators together with respect to the associated heuristic in the *Heuristic No*. column. The *By single expert* column represents the number of problems identified by one expert evaluator only (not necessarily the same expert).

Discussion of Table 7.7 and Table 7.8

Table 7.7 and Table 7.8 show that more problems emerged from Heuristics 2, 3, 6, 7, 11 and 18 (five to seven) when compared with the rest. These particular heuristics and the associated problems identified in Info3Net are briefly discussed:

- For Heuristic 18, two of the problems were each identified by three experts. In fact all four experts identified some problem in relation to Heuristic 18. This indicates that, according to the experts, the system was lacking in terms of feedback and guidance to the learners.
- Similarly, all the experts identified some problem relating to Heuristic 6. These problems were mainly because some labels or instructions were confusing or not clear.
- The fact that many problems were found with regard to Heuristics 3 and 11, probably indicates navigational and user control difficulties within the application.
- Four of the six problems in Heuristic 2 (2.1 to 2.4) were identified by the same evaluator (Evaluator 3) showing that this evaluator found labels or icons not to be meaningful. The other two problems in relation to Heuristic 2 (2.5 and 2.6) were identified by Evaluator 2 and are connected with the visual layout of the website.
- For Heuristic 7, the main problem, identified by three evaluators, was that the system could not be customised.
- Problem 6.1 regarding confusing labels or instructions, was identified by all four expert evaluators. This shows a lack of correspondence between actions and their results or between controls and their operations, i.e. problems relating to visibility. These problems occurred mainly because certain labels or instructions were confusing or unclear.

The heuristics in the expert evaluation were generated, in Chapter 5, from theoretical foundations that, among others, advocate interactivity, visibility, feedback, customisation and flexibility in learning environments. These evaluation criteria have served well in identifying deficiencies in Info3Net, by highlighting similar areas of concern to those raised in the learner-evaluation. These should be addressed in its future upgrades, as far as is possible within the constraints of WebCT^{TM}.

Analysis of Table 7.8 shows that there was a tendency for each evaluator to identify several problems with respect to one or two heuristics. For example, of the nine problems identified by Evaluator 1, four of them were for Heuristic 18. Likewise for Evaluator 2, five of the twenty she identified were for Heuristic 11, and for Evaluator 4, five of the twenty two problems she identified were for Heuristic 7. This shows that that there was a tendency for an evaluator to concentrate on problems associated with particular evaluation criteria. However for Evaluator 3, the number of problems identified for each criterion was more widely distributed. In total, she also identified the highest number of problems.

As stated before, the *By single expert* column in Table 7.8, represents the number of problems identified by only one expert evaluator. The total for this column constitutes 71% (41 out of 58) of all the problems identified by the experts. This means that 29% (100% minus 71%) of the problems were identified by more than one evaluator, which indicates a low level of agreement among the experts as to what the problems were. Further analysis of the data in Table 7.8 shows that this is mainly due to the fact that different experts tended to concentrate on different heuristics while doing their evaluations. Table 7.9 shows, for each evaluator, the heuristic for which she identified the highest number of problems. This information is extracted from Table 7.8.

Evaluator	**Heuristics with highest two values (number of problems) as indicated in Table 7.8**
1	No. 18
2	No. 6 and No. 11
3	No. 2 and No. 6
4	No. 3 and No. 7

Table 7.9: Heuristics for which evaluators identified the highest number of problems

The two highest values are given, except in the case of Evaluator 1 where one value only is given since the second highest value is one (and there are five cases of ones). Table 7.9 shows, for example, that the highest numbers of problems identified by Evaluator 2 (three and five problems – see Table 7.8), were with respect to Heuristics 6 and 11 respectively.

Discussion of Table 7.9

The data in Table 7.9 shows that, except for one heuristic (Heuristic 6) common to Evaluator 2 and Evaluator 3, different evaluators identified their highest number of problems in the context of different heuristics. This indicates, as stated before, that they tended to concentrate on different aspects.

7.3.6.2 Final list of problems and the percentages identified by individual evaluators

When the **58** problems identified by the expert evaluators (Table 7.7) were combined with the **55** identified by the learners (Table 7.1), the final consolidated list of problems comprised a total of **75** problems. This list is given in Appendix C-1 (in the format used for the severity rating of the problems). These 75 problems cannot be considered to be the ultimate diagnosis of all problems that exist in the application but, as in similar studies (Lindgaard, 2004), they can be assumed to be the most evident ones.

With this background, the percentage of total problems identified by each evaluator can now be calculated. Table 7.10 shows the number of problems identified by each evaluator, the percentage this comprises of the problems identified by experts only, and the percentages when the combined list of **75** problems is considered. It is interesting to note that, between them, the set of experts identified 77% of the problems on the final list. These percentages of the combined list are also shown in the graph in Figure 7.2. It is these percentages – in the last row – that are referred to in the discussions that follow, so that the results in this study are analysed in relation to those in similar studies.

Evaluator	**1**	**2**	**3**	**4**	**Total (Experts only)**	**Total (Combined)**
Number of problems identified	9	20	31	22	58	75
% of problems identified by experts	16%	34%	53%	38%	100%	
% of all (combined) problems	12%	27%	41%	29%	77%	100%

Table 7.10: Numbers and percentages of problems identified by evaluators

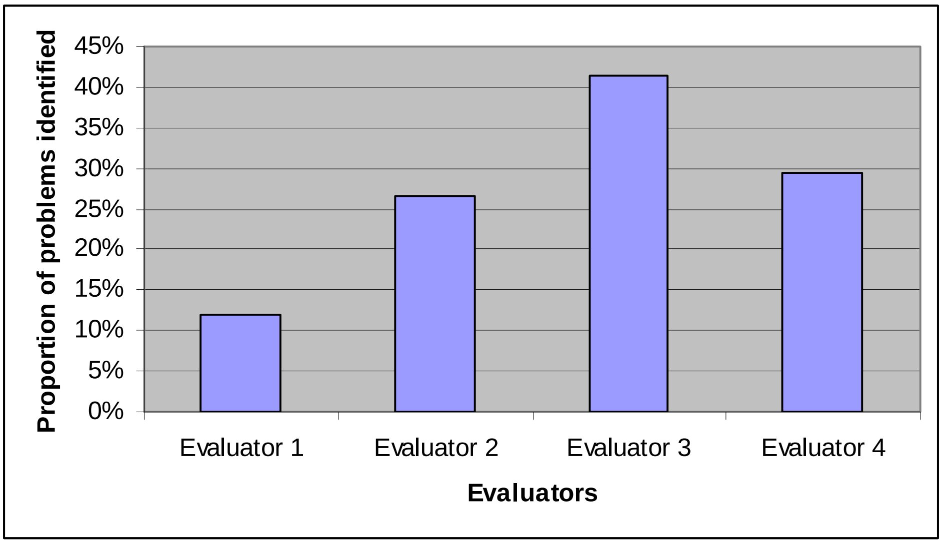

Figure 7.2: Proportion of problems identified by each evaluator

Discussion of Table 7.10 and Figure 7.2

The percentages in Table 7.10 and Figure 7.2 range from 12% to 41%. In general, these percentages are in line with findings of similar studies (Nielsen, 1994:44; Nielsen & Molich, 1990:255; Peng et al, 2004:46), which show that a single evaluator usually finds 20% to 50% of the problems in a system.

It can be noted that Evaluator 1 identified less problems (12%) than the others (27% to 41%). As indicated in Section 7.3.4, this is the only evaluator who performed the evaluation within the required time period and who did so without any assistance in clarification of issues or anyone to act as a scribe. She took two hours to do the evaluation. The others took one to one-and-a-quarter hours, on average, but as indicated in Section 7.3.4, they did it in the presence of the researcher, who noted the problems while they evaluated. The fact that these three performed the evaluation in considerably less time than that taken by Evaluator 1, confirms the suggestion by Nielsen (1994:40 – see Section 7.3.4) that this approach speeds up the evaluation process.

The number and nature of problems identified by each evaluator can possibly be related to their backgrounds – see Table 7.5. For example, the lower number of problems identified by Evaluator 1 can be attributed to the fact that she is an expert in education theory and educational technology, but she has not studied or taught Human Computer Interaction (HCI) as a subject and does not have experience of HE as an evaluation methodology. This evaluator is considered to be a 'single expert', in contrast to a 'double expert', as described in Sections 4.9.1.1 and 7.3.2, where it is stated that such an evaluator is likely to identify fewer problems than one who has experience in both HCI and education.

Evaluator 4 has a similar background to that of Evaluator 1 in terms of formal training, yet she identified far more problems than Evaluator 1. This could be attributed to the fact that, unlike Evaluator 1, Evaluator 4 has designed e-learning applications using WebCT™, the course management software that was used in the design of the application used in this study. Furthermore, she lectures Internet programming, making her basically a 'double expert'. Her experience as a teacher and a designer, and the feedback she has been getting from her learners, helped her to identify problems in such applications. For example, one of her comments was "Many students have criticised systems designed using WebCT™ for not being customisable".

Evaluator 2 has considerable experience in HCI and heuristic evaluation in particular. She has no formal education theory training although she is an educator (senior lecturer). Although, she too can be classified as 'single expert', she identified a high number of problems.

As stated before, in Section 7.3.2, Evaluator 3 has masters degrees in both Information Systems and Education. She lectures HCI at postgraduate level. She can be described as a 'double expert' since she has experience in both HCI and the domain area of evaluation for this application, which is education. She identified the highest number of problems in the application. As stated in Section 4.9.1.1, experts with both domain and HCI knowledge discover a high proportion of usability problems. This is confirmed in a study by Nielsen and Phillips (1993:217) which found that usability specialists are better than non-specialists at finding usability problems. In addition to this, HE experts need skills and experience in domain and usability evaluation (Kantner & Rosenbaum, 1997:154). Although HEs are most valuable and authoritative ways of identifying usability problems, the findings depend on evaluator's skills and experience and therefore the findings of different experts may vary (Ardito et al, 2006:274).

7.3.6.3 Percentage of problems identified by a set of evaluators

Using the number of problems identified by individual evaluators, the average number of problems identified by a given number of evaluators can be determined, by calculating the mean of these values (Law & Hvannberg, 2002:77; Nielsen, 1994:44). This is done in Table 7.11, which also shows these problems as a percentage of the total of 58 problems identified by the experts.

Discussion of Table 7.11

Table 7.11 shows the average number of problems identified by combinations of one, two and three evaluators respectively and how these figures were obtained. For example, the average number of problems identified by a single evaluator is calculated by finding the mean of the number of problems identified by Evaluator 1 (9 problems), Evaluator 2 (20), Evaluator 3 (31) and Evaluator 4 (22) which gives an average of **21 –** which is **36%** of the 58 problems identified by the experts. These figures are shown in Table 7.11. Likewise the average number of problems for two evaluators is calculated by finding the mean of the number of problems identified by the different combinations of two evaluators. For example, Evaluator 1 and Evaluator 2 together identified 27 problems (see Table 7.11). This is the number for the problems identified by either of them or by both. This figure is determined for each combination of two evaluators, i.e., also for Evaluators 1 and 3; 1 and 4; 2 and 3; 2 and 4; and 3 and 4. The mean of these figures gives the average number of problems for two evaluators. This number and its percentage in relation to the 58 problems identified by the experts is shown in the table. Similarly, the average number of problems and corresponding percentage, for three evaluators can be determined. The number of problems identified by four expert evaluators, **58**, is the total number of problems identified by all the evaluators as discussed in Section 7.3.6.2 and given in Table 7.10.

Problems identified by a set of experts		
Experts evaluators involved	**Number of problems identified**	**% of problems**
Evaluator 1	9	
Evaluator 2	20	
Evaluator 3	31	
Evaluator 4	22	
Average for one Expert	**21**	**36**
Evaluators 1 & 2 together	27	
Evaluators 1 & 3 together	36	
Evaluators 1 & 4 together	28	
Evaluators 2 & 3 together	44	
Evaluators 2 & 4 together	38	
Evaluators 3 & 4 together	41	
Average for two Experts	**36**	**62**
Evaluators 1, 2 & 3 together	49	
Evaluators 1, 2 & 4 together	43	
Evaluators 2, 3 & 4 together	53	
Evaluators 3, 4 & 1 together	46	
Average for three Experts	**48**	**83**
All experts evaluators (1, 2, 3 & 4)	**58**	**100**

Table 7.11: Calculation of average number of problems identified by expert evaluators

The next step is to use these figures to determine the average percentage of problems identified by a specific number of evaluators, with respect to the **75** problems in the combined list of problems (experts and learners). Table 7.12 shows this and Figure 7.3 gives the graph of the same data.

Number of Evaluators	**1**	**2**	**3**	**4**
Average number of problems identified	21	36	48	58
% of 75 problems identified by experts and learners	28%	48%	64%	77%

Table 7.12: Average percentages of problems identified by expert evaluators

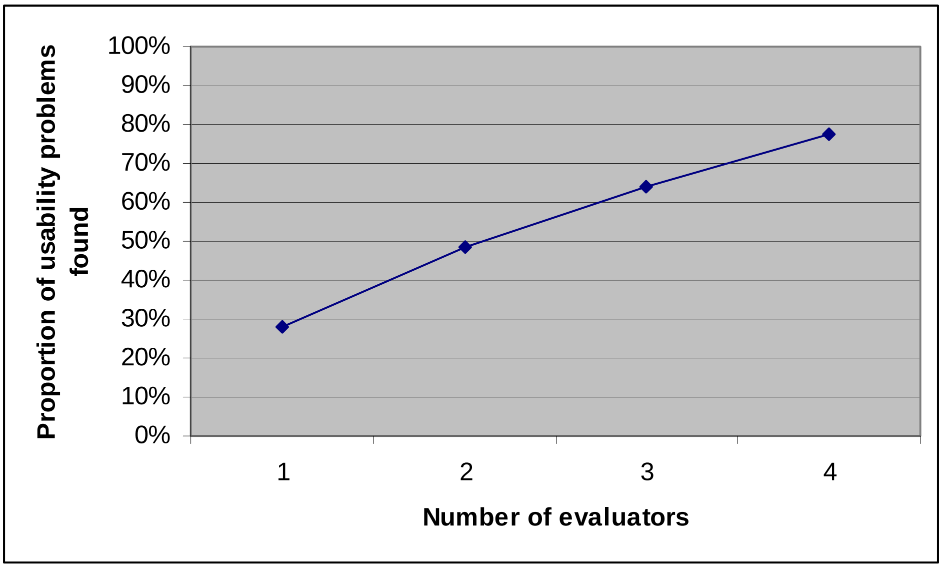

Figure 7.3: Proportion of problems in the system found by various evaluators

Discussion of Table 7.12 and Figure 7.3

The data in the graph in Figure 7.3 shows that one evaluator, on average, identified 28% of the problems. This confirms the results of a study by Nielsen and Molich (1990, 255) which shows that one cannot rely on a single person to perform a heuristic evaluation. The average of 28% is comparable to the results found in similar studies, where the values range from 29% (Nielsen, 1994:44) to 34 % (Law & Hvannberg, 2002:77). The graph shows that as the number of evaluators increases, the proportion of problems identified increases too. However, the rate of increase reduces as the number of evaluators increases. The graph shows that the four evaluators were able to identify 77% of the total 75 problems, as stated in already in Section 7.3.6.2.

In order to compare the results of this study with similar studies, the graph for this study, Figure 7.3, is now drawn on the same axes as the graph from a study by Nielsen, previously given in Figure 4.3 and discussed in Section 4.9.1.1. The integrated graph is presented here as Figure 7.4.

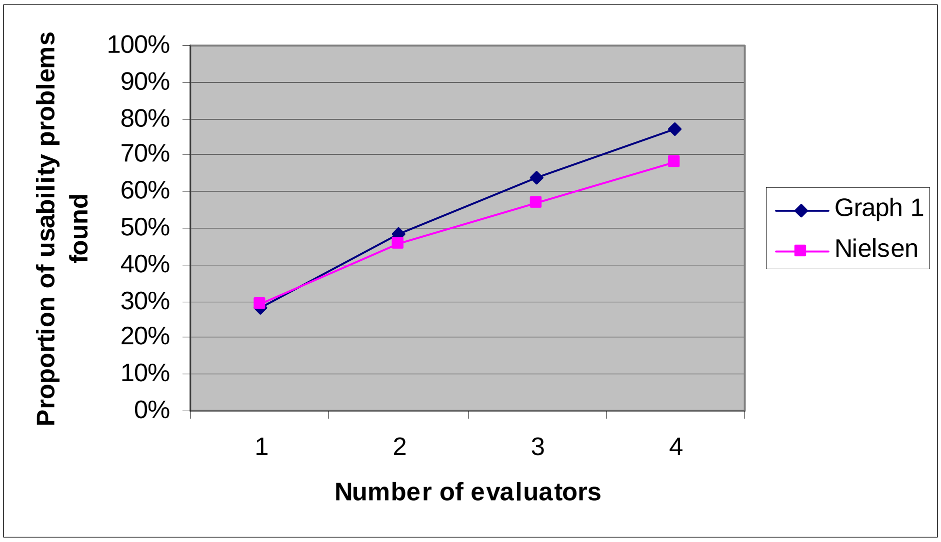

Figure 7.4: Graph of the current case study (Graph 1) compared with that by Nielsen's study (Nielsen, 1994:33)

Discussion of Figure 7.4

The graphs are named 'Graph 1' and 'Nielsen' respectively. The two are very similar in shape and correspond closely.

- Both start from almost the same point (29% for Nielsen's graph and 28% for this study for the case of a single evaluator).
- For two, three and four evaluators, the values for Graph 1 are 51%, 64% and 77% respectively. The corresponding values for Nielsen's graph are 46%, 57% and 68 %.

As illustrated in Figure 7.4, the graph for this case study, Graph 1, is slightly higher than that of Nielsen, except at the starting point. This means that the proportion of problems identified in this case study is higher than the proportion in the study by Nielsen. This is highly satisfactory and could be due to various factors. One possible reason could be the diligence with which the expert evaluators undertook their task and identified a high proportion of problems in this study.

The fact that four evaluators identified 77% of the problems is close to, but better than, Nielsen's findings, discussed in Section 4.9.1.1, that three to five evaluators will identify about 75% of the problems.

More analysis of the HE results, together with results from the learner survey, is done in the next section, where the two sets of findings are compared.

7.4 Comparison of Survey and Heuristic Evaluation Results

7.4.1 Overall comparison

In comparing the results of the learner survey and the heuristic evaluation, the list of 55 problems identified by learners excludes the eight problems that emerged from the criteria not presented to the experts (Heuristics 12, 15, 16, 17 and 19 – see Appendix B-1 and Appendix C-1). Among other reasons, as discussed in Section 7.2.5 and 7.3.1, this was done to make the two sets of problems fully comparable.

Table 7.13 shows the number of problems identified by experts and learners for each criterion, the number of *Common* problems identified in both evaluations. The table shows that in total, 75 problems were identified. Of these, 58 were identified by experts and 55 by learners, as discussed in Sections 7.2.5 and 7.3.6.1 respectively, and 39 were identified by both groups. This means that the experts identified 77% of all the problems and the learners 73%. Even though the number of learners, namely 61, who participated in the evaluation, was significantly more than the number of expert evaluators, namely 4, the former (very large group) identified fewer problems than the latter (small group). This is in line with Nielsen's claim that end users are not good at identifying usability problems in a system since they have a "poor conceptual understanding of usability and computer principles" (Nielsen, 1994:59) and similarly of learning principles. However, since the experts identified over three-quarters of the problems (77%), the present findings support the statement by Nielsen and Molich (1990:250) that even experts are not perfect in identifying usability problems.

Table 7.13 also shows the interesting result that more than half, 52 % (39 out of 75), of all problems were identified by both groups. Furthermore, the learners identified 39 of 58 (67%) of the problems identified by experts. Similarly, the experts identified 55 (71%) of the problems identified by learners. The facts in this paragraph demonstrate a correspondence between the results of the two evaluations

Criterion	Number of problems identified			
	Experts	**Students**	**Common**	**All**
1	4	2	1	5
2	6	3	3	6
3	5	5	5	6
4	3	5	3	5
5	2	3	2	3
6	5	2	2	5
7	6	6	5	7
8	3	4	3	4
9	1	3	1	3
10	3	4	2	5
11	7	5	2	10
13	4	3	3	4
14	1	2	1	2
18	6	6	4	8
20	2	2	2	2
Total (General)	**38**	**37**	**27**	**49**
Total (Web)	**7**	**5**	**2**	**10**
Total (Educational)	**13**	**13**	**10**	**16**
Total (All Problems)	**58**	**55**	**39**	**75**
% of all 75 problems	77%	73%	52%	100%
% of other group's problems	71%	67%		

Table 7.13: Number of problems identified by learners and by experts

This study is based on the premise that HE is inexpensive, easy, and fast to perform when compared to other evaluation methods, as stated in Section 1.4.3. Issues of cost and time, therefore, were not formally investigated in this study. However, the present researcher expended considerably less time and effort in the heuristic evaluation than in the survey evaluation, with respect to matters such as the preparation of materials, conducting the evaluations, and the analysis of data. For example, only four sets of evaluation results were analysed in the case of HE as compared to 61 sets in the survey, yet, due to their experience and expertise, the four experts identified 77% of the set of combined problems and 71% of the problems identified by the group of learners. These factors make HE a relatively easy-to-conduct and cost-effective method, as the researcher experienced in this case study comparing two different evaluation methods.

7.4.2 Comparison according to the evaluation criteria categories

Figure 7.5 shows the graph of the number of problems identified in the three different categories of criteria used in the evaluation, namely General, Web and Educational criteria (see Categories 1, 2 & 3 in Table 7.7 in Section 7.3.6.1). The numbers in the figure are extracted from Table 7.13.

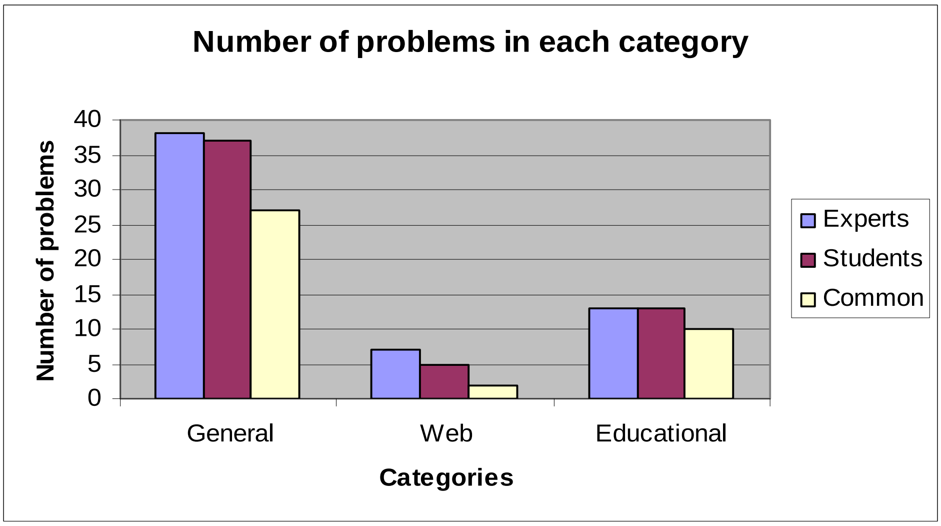

Figure 7.5: Graph of the number of problems identified, and common ones, for each category

Discussion of Figure 7.5

Figure 7.5 shows that almost the same number of problems was identified in each category by experts and learners and that in each category there were a number of problems identified by both groups. When all the problems in the three categories are considered there are subtotals of 49, 10 and 16 problems in the General, Web and Educational categories (see Table 7.13), respectively, corresponding to 65%, 13% and 22% of the total of 75 problems. This can be attributed to the fact that there were ten, one and five criteria to consider in the corresponding categories. The data thus indicates that more problems were identified in cases where there were several criteria in a category and vice-versa.

Table 7.14 shows the percentages, within each category, of problems identified by experts and learners and Figure 7.6 shows the corresponding graph.

	Experts	**Students**	**Common**
General	78%	76%	55%
Web	70%	50%	20%
Educational	81%	81%	63%

Table 7.14: Percentages, within each category, of problems identified

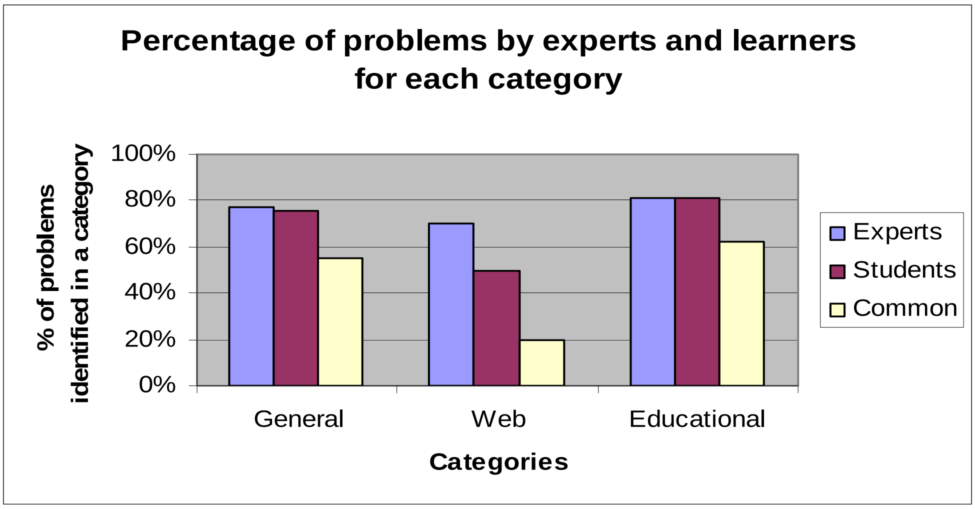

Figure 7.6: Graph of percentages, within each category, of problems identified

Discussion of Table 7.14 and Figure 7.6

It should be noted that the percentages in Table 7.14 and Figure 7.6 are in relation to the total number of problems in a category. For example, Table 7.13 shows that experts identified seven out of ten problems in the Web category, and therefore a value of 70% is shown in Table 7.14 and in the corresponding graph in Figure 7.6. The graph shows that the experts and learners identified the highest, and identical, percentages of problems in the Educational Category (both 81%) followed by the General Category (78% and 76% respectively). The lowest percentages were in the Web Category (70% for experts and 50% for learners), where the percentage of problems identified by experts was 20% more than that identified by learners. The graph also shows that the highest percentage of common problems was in the Educational Category (63%), followed by the General Category (55%) and that only a small percentage (20%) of problems were identified by both the experts and learners in the Web category. This means that there was considerable agreement on the problems relating to the Educational and General category but not so in the Web category. The most likely reason is that there was only one heuristic to consider for evaluation in the Web Category compared to ten and four in the General and Educational Categories respectively.

Figure 7.7 shows the graph of the number of problems identified by both groups (experts and learners) for each criterion (see Table 7.13).

Discussion of Figure 7.7

It can be seen from Figure 7.7 that the results of the two groups correspond closely. For example, where the learners found a high number of usability problems (five or more), such as for Heuristics 3, 7, 11 and 18 (see Table 7.13 or Appendix B-1), the evaluators did the same.

Examination of Appendix C-1 shows that in 14 out of the 15 heuristics, the top two problems identified by the highest number of experts, correspondingly have the highest number of students who identified the same problem under that criterion. This correspondence further emphasises the level of agreement between the learners and experts on the problems in the application.

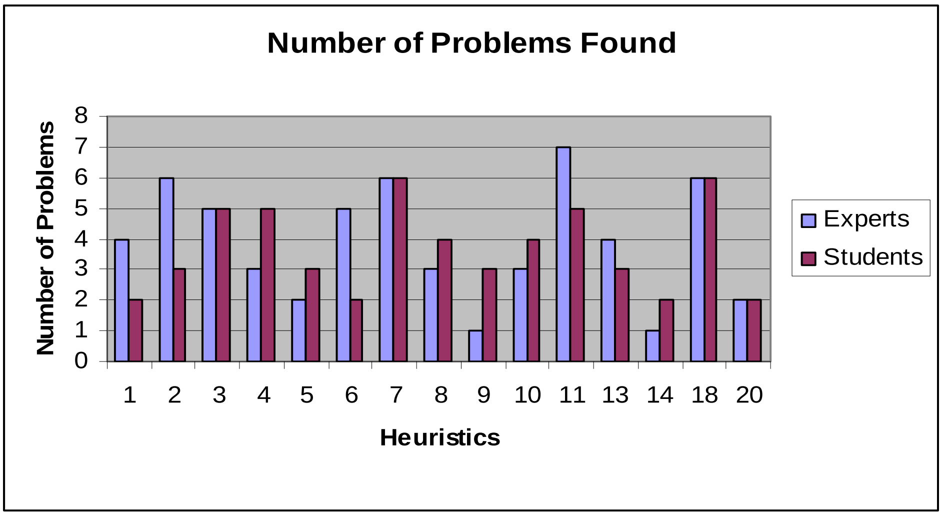

Figure 7.7: Number of problems identified by experts and learners for each criterion

7.4.3 Severity rating of the problems by experts

As discussed in Section 7.3.5, each of the four expert evaluators independently rated the severity of the problems in the combined list of 75 identified problems, on a scale of 1 to 5 (Cosmetic, Minor, Medium, Major, Catastrophic). Appendix C-1 presents the rating scale, along with the 75 problems, and Appendix C-2 shows each expert's rating and the average rating of each problem. The mean of the averages is 3.0 with a standard deviation of 0.8. This indicates that most problems were considered by the experts to be 'Medium problems', in that users could quickly adapt to them and make satisfactory use of Info3Net. From the Appendix, the mean scores for Evaluators 1 to 4 were 3.1, 3.2, 2.9 and 2.8 respectively. Each of these figures is close to the overall mean score of 3.0. Although this on its own does not show that there was general agreement on the severity rating of the different problems, a closer look at the appendix shows that this was indeed the case, i.e. most problems were allocated very similar scores by all the expert evaluators.

Appendix C-3 shows the severity rating data when only the first two problems for each criterion (see the criteria and the problems in Appendix C-1) are considered. The data in Appendix C-3 (compared to that of Appendix C-2) shows that the mean of the averages of the ratings increases from 3.0 to 3.5. Since the ordering of the problems in Appendices C-1, C-2 and C-3 is presented in decreasing order, according to the number of expert evaluators who identified a particular problem, the increase in the mean value indicates that problems identified by many expert evaluators were generally rated higher than those identified by fewer evaluators. However, this was not always the case. For example, whereas Problems 7.1 and 7.2 were identified by three and two different experts respectively (see Appendices C-1 and C-2), the average rating of each of these two (2.8) is lower than that of Problems 7.4 and 7.5 (both with an average rating of 3.0), each of which was identified by a single expert only. This shows openness on the part of the experts to rate severely a problem that they themselves had not personally identified. This demonstrates credibility and lack of bias on the part of the expert participants in this case study.

7.4.4 Minor and major problems

As discussed in Section 4.9.1.5, the purpose of severity rating is to determine the seriousness of usability problems. Such problems could be major or minor. As set out in Table 7.6 and discussed in Sections 7.3.5 and 7.4.3, a five-point Likert scale was used to rate the severity of the problems. Data is now extracted from the results of the experts' ratings in Appendix C-2 in such a way that those problems with an average of 4 to 5 (Major to Catastrophic) are viewed as 'major' problems and those with an average of 1 to 2 (Cosmetic to Minor) as 'minor' problems. The number of problems in the major and minor categories and their corresponding percentages are given in Table 7.15, with a corresponding graph in Figure 7.8.

	Experts	**Students**	**Common**	**All**
Major problems	11	11	10	12
% of Major problems identified by:	92%	92%	83%	100%
Minor problems	8	5	1	14
% of Minor problems identified by:	57%	36%	7%	100%

Table 7.15: Number and percentages of problems identified by experts and learners for major and minor problems

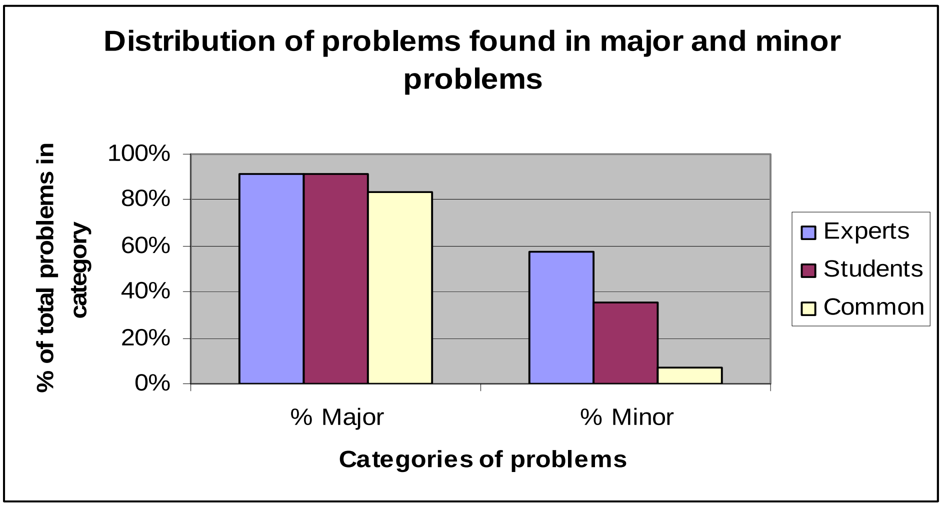

Figure 7.8: ***Graph for the percentages of problems identified by experts and learner for major and minor problems***

Discussion of Table 7.15 and Figure 7.8

Twelve problems are thus found to be *major* and fourteen are *minor*. This means that of the total 75 problems, 49 problems with average ratings of more than 2 but less than 5 are excluded from this set.

Major problems

Table 7.15 shows that of the twelve major problems, experts identified eleven of them, learners eleven and ten problems were identified by both groups. This corresponds to 92%, 92% and 83% as seen in the Table 7.15 and the graph in Figure 7.8. Secondly, since ten problems were common, it means that of the problems in the *major* category, ten of the eleven identified by learners, i.e. 91%, were also identified by the experts, compared to 71% (39 of 55) that were identified when all the problems were considered as discussed in Section 7.4.1 and shown in Table 7.13. This indicates that both sets of evaluators, experts and learners, identified a high percentage, i.e. 92%, of major problems, and that there was consensus that these problems occur in Info3Net. In fact, out of the twelve problems in the major category, only one problem was identified by experts but not by learners, and one by learners but not by experts.

Minor Problems

Table 7.15 and the graph in Figure 7.8 also show that of the fourteen *minor* problems identified, the expert evaluators identified eight (57%) of them, learners five (36%) and only one (7%) was identified by both groups. Only one problem was common, which means that of the five problems identified by learners in the minor category, only one, i.e. 20%, was also identified by the experts, and only one of the eight identified by experts was recognised by learners. This data shows that both sets of evaluators, experts and learners, identified a low percentage of minor problems and that there was little agreement, namely, 7%, on what these problems were.

Discussion

These results support similar studies (Nielsen, 1994:56; Law & Hvannberg, 2002:77) which show that major problems are easier to find than minor ones. In the present study, both sets of evaluators identified 92% of the major problems, compared to 57% by experts and 36% by learners in the minor-problems category. Nielsen (1994:56) adds that – although major usability problems are easier to identify – when all problems are considered, the number of minor problems will exceed the number of major ones, which was the case in the present study.

Without going into detail regarding the nature of major and minor problems identified, a few examples of characteristics of the problems in this case study are now addressed. The top three major problems were concerned with system navigation and error recovery issues. These are given in Table 7.16 along with the number of experts and learners who identified them.

Problem	**Number of experts**	**Number of students**	**Average severity**
There are no facilities for Undo and Redo.	2	16	4.8
The error messages given are not helpful, for they do not provide any instructions for recovery.	2	7	4.5
Apart from the buttons provided by the browser, there should be a Back/Previous and Forward/Next button within the application.	0	19	4.5

Table 7.16: Top three major problems

Discussion of Table 7.16

According to Table 7.6 in Section 7.3.5, the first two problems in Table 7.16 can be classified as catastrophic. If users have no way to return to the previous stable state of a system and cannot get help on how to do so, then they remain 'stuck' in the system. It is also important to note that at least two experts and a fairly high number of learners (16 and 7 respectively) identified these two problems. This further confirms the view that major problems are easy to identify.

The third problem can be classified as a major problem, using the classification in Table 7.6. Though users will find it difficult to navigate the system without Back/Previous and Forward/Next buttons they can work around this problem by using the button on the browser to move back and forward. It is interesting that no expert actually identified this problem, but they rated it highly in terms of its severity. This can probably be attributed to the fact that they have more experience than learners in using the Web, and consequently used the alternative button on the browser. Another notable inference, already mentioned in Section 7.4.3, is that the expert evaluators were not biased in the severity rating, since they rated a problem highly even when they had not recognised it themselves.

Table 7.17 shows the three least serious (Cosmetic) problems identified in the application using the results of the severity rating.

Problem	Number of experts	Number of students	Average severity
There are no facilities for synchronous communication such as video conferencing.	0	1	1.3
There should be lines between the different windows in a two- or three-window design	1	0	1.5
In order to improve readability, the Course Menu should be wider, and the spaces between its different sections should be larger than the spaces between items of the same sections.	1	0	1.7

Table 7.17: The three most minor problems

Discussion of Table 7.17

The problems in the table can be classified as minor, according to Table 7.6, since none of them will affect actual use of the system. The first problem, regarding the lack of video conferencing facilities, will not affect the use of Info3Net. This issue was raised by a single learner as one of the ways to improve collaborative learning. Although the point is valid, the system could be used collaboratively without including such a facility. The last two problems in the table will clearly not affect the use of the system, though they could marginally reduce the speed of performing certain tasks as they affect the visual layout of the windows and menus.

Analysis of Table 7.16 and Table 7.17 shows that higher numbers of evaluators (experts and learners) identified the top three major problems when compared to the number that identified the three most minor problems. This supports the statement earlier in this section that major problems are easier to find than minor ones.

This section has analysed and compared the results of the survey evaluation among learners and heuristic evaluation by experts. The final section of this chapter gives a summary of the main findings and conclusion.

7.5 Summary of Main Findings and Chapter Conclusion

The Information Systems 3 e-learning website, Info3Net, created with WebCT™ was evaluated by 76% of the end users (learners), 61 in total, using survey methods. This entailed questionnaires administered to the participants, followed by a focus group interview. Before the questionnaire survey was conducted, a pilot study was done with a few learners. This was found to be very useful, as the feedback from the pilot study identified shortcomings that would have affected the evaluation process negatively. Likewise, the focus group interview enriched the findings, as it clarified certain issues raised by learners in their responses to the questionnaire and identified problems in the application that had not been identified by responses to the questionnaire. After consolidation, the set of problems identified by learners comprised 55 problems.

Info3Net was then heuristically evaluated by four expert evaluators. After consolidation, the set of problems identified by experts comprised 58 problems. When the experts' and learners' problems were integrated, the final set of problems contained 75 problems. The percentage of problems identified by the aggregated group of experts as a factor of this final set was thus 77%, a most satisfactory achievement by a group of only four experts. The input from the expert evaluators varied in terms of the number of problems they identified. The percentage of problems found by each individual ranged from 12% to 41% of the consolidated set of problems with an average of 28%. This shows that one cannot rely on a single expert to perform an evaluation of a system, as pointed out by Nielsen and Molich (1990, 255). The literature suggests that three to five expert evaluators should be used, depending on the complexity of the system to be evaluated and on the knowledge and experience of the evaluators in the domain area, i.e. subject matter expert/s, and HCI, i.e. usability experts/s. In general, the evaluators with experience, or knowledge of HCI discovered more problems than those without HCI expertise, showing that previous exposure to usability evaluation plays a positive role in the application of heuristic evaluation.

In this case study, there was a tendency for each expert to concentrate on problems associated with certain evaluation criteria at the expense of the others. The end result was that more problems were identified with respect to these criteria. When the criteria that different experts emphasise are not the same, the various heuristic evaluations are complementary resulting in few problems being identified by more than one evaluator. This was the situation in this study.

It can be difficult for evaluators other than learners themselves to use some of the criteria related specifically to learning. Criteria that aim to determine whether learners were able to learn using the system, or whether they had a sense of ownership over Info3Net, were therefore excluded from the heuristics used by the experts. However, learners using these criteria identified certain problems vital in terms of learning. This supports the suggestion by Kantner and Rosenbaum (1997:153) and Lindgaard (2004) that, ideally, heuristic evaluations should be supplemented by feedback from end users, using methods such as user interviews and surveys.

One of the issues that the researcher of this study realised both during the evaluation by experts and the evaluation by learners, is that evaluators should be allowed ample time to perform their evaluations. This is because they work backwards and forwards, needing to check the application to determine what the problem is, or to establish further clarity on a problem they have already encountered. More time is thus required to describe it and/or write it down. During the observation of evaluations by the researcher, this process was a challenge to both groups of evaluators. The challenge becomes even greater when the evaluator has to determine which heuristic/s is/are violated by a particular problem.

Although, as stated, issues related to cost and time were beyond the scope of this study, the researcher expended less time and effort on the processes of heuristic evaluation than on the survey evaluation. This supports findings (Belkhiter et al, 2003:178-185; Blandford et al, 2004:28; Karoulis & Pombortsis, 2003:93-97; Lindgaard, 2004) that HE is inexpensive, efficient, and easy to conduct, when compared to other usability evaluation methods.

Some of the evaluation criteria used in the study were derived from theoretical concepts based on learning theories such as constructivism. The target system of the study, Info3Net, was not developed on the basis of these concepts, mainly because its development environment, WebCT™, does not easily support them. However, the evaluation criteria played a major role in identifying deficiencies in Info3Net. This confirms the integrity of these criteria, and has a further benefit of identifying areas in Info3Net that should be addressed when it is upgraded or re-engineered in the future.

Severity rating of problems identified in the application was found to be a particularly valuable exercise. It helps to determine which problems are major and which are not.

Although the learners had been using Info3Net for some time, they identified a slightly lower proportion of the total problems, 73%, when compared to the 77% of the four expert evaluators. This confirms the statement made by Nielsen (1994:59) that end users are not as good as expert evaluators in identifying usability problems. The proportion of problems identified rose to the same value for both groups, namely 92%, when only the set of the major problems was considered. This was done by extracting and analysing data relating to those problems only. The increase in the proportion identified shows that it is easier, for both learner and experts, to identify major problems than minor ones.

A further notable finding is that the four expert evaluators were able to identify more than two-thirds (71%) of the problems identified by the learners, while learners identified 67% of the problems identified by the experts. The percentage of learner-identified problems also identified by experts rose to 91% when the set of major problems only was considered. This proportion fell to 20% for the set of minor problems. It was also found that, in general, for the heuristics where experts identified a high number of problems, the learners did the same and vice-versa.

To summarise, the conclusion from these findings in a comparative case study (Section 1.6.4) is that the results of heuristic evaluation by experts correspond well with those of survey evaluation among end users (learners). In fact, the HE results are better than the survey results (see Table 7.13). They were produced by only four experts compared to 61 learners, yet in total the experts identified 58 problems compared to the learners' 55, and the percentage of all problems identified by HE was 77%, while the percentage identified by the learner survey was 73%. At the beginning of Section 1.6, it was stated that an aim of this research was to determine whether heuristic evaluation, when applied to web-based e-learning applications, is sufficient for identifying usability problems, where 'sufficient' is taken to mean adequate identification of problems that users themselves point out. In this study, the experts identified 71% of the learner-identified problems and 91% of the learner-identified problems when major problems only are considered. These facts would indicate that HE has demonstrated itself to be a sufficient and highly effective usability evaluation method, as well as relatively easy to conduct, and it is known to be inexpensive, as also pointed out in a recent article by Ardito et al (2006:274).

Certain evaluation criteria were presented to learners but not to the expert evaluators, since they were directly relevant to learners only. However, even when using the same set of criteria, learners identified some problems that the experts did not, which shows that the end-user survey results did indeed add value to the evaluation. Therefore, while heuristic evaluation is good at identifying usability problems in web-based e-learning applications, particularly the major problems, it can be enhanced by supplementary user-based evaluation methods. Despite this, the author of this dissertation recommends heuristic evaluation as the most suitable method for usability evaluation of web-based e-learning applications in cases where only one method can be applied.

Chapter 8: Research Summary and Further Research

8.1 Introduction

In this chapter, the major issues of the study are summarised. Section 8.2 provides a brief summary of what has been achieved. Section 8.3 provides answers to the research questions posed in Chapter 1. This is followed by recommendations for further research in Section 8.4. The final conclusion is provided in Section 8.5.

8.2 What has been Achieved

Given that heuristic evaluation (HE) is known to be easy to use and cost effective, this study set out to determine its effectiveness in identifying usability problems in a web-based e-learning application. The investigation was conducted by designing and conducting both a heuristic evaluation by experts and a survey evaluation among learners and comparing the results of the two. A case study methodology was applied in the investigation. The target system used in this process was a web-based e-learning application, Info3Net, in the context of tertiary institution

As a basis for this study, current literature was reviewed in the fields of education and human computer interaction (HCI), the two main domains of this study. Chapter 2 deals with some of the major current learning theories such as constructivism, since careful consideration of these theories is important for effective teaching and learning. The content of Chapter 2 builds up to Chapter 3 where instructional design and current e-learning models (both of which are, in general, based on the learning theories discussed in Chapter 2) are discussed. Guidelines for teaching and learning in a web-based learning environment are also suggested. The HCI aspects of the study are addressed in Chapter 4, where HCI models of interaction as well as usability principles and design, are overviewed. However, the major component of Chapter 4 identifies, discusses and compares the main usability evaluation methods.

In an effort to integrate usability and learning, a set of evaluation criteria suitable for evaluating web-based learning applications is generated in Chapter 5(see Figure 5.3 in Section 5.4). Most of the criteria are derived from Chapters 2, 3 and 4. These synthesised criteria are used in the actual evaluation of Info3Net, described in Chapter 7.

Using WebCT™, a course management system, a web-based e-learning application, Info3Net, was designed and developed for a 3rd year Information Systems course at Walter Sisulu University (WSU) in accordance with steps suggested by Li (2003) – see Table 6.1 in Section 6.4. The website was developed to supplement face-to-face classroom instruction and to work as a target system for research on evaluation. Heuristic evaluation by experts and survey evaluation among learners were performed, and the results compared. The results of the two evaluations and the analysis are used in Section 8.3 in answering the research questions.

8.3 Answers to the Research Questions

The **primary research question** for this study, posed in Section 1.2.1, is:
"To what extent can heuristic evaluation identify usability problems of web-based e-learning applications in a tertiary institution?".

In order to answer this question, two subquestions were posed in Section 1.2.2:

- **First subquestion:** *"What criteria are appropriate for usability evaluation of a web-based learning environment for a 3rd year Information Systems course in a tertiary education institution?"*

This was answered in Chapter 5 where a set of criteria/heuristics that support both learning and usability were defined. These and their associated sub-criteria were used by both the learners and experts to evaluate Info3Net. The criteria identified can serve a further valuable purpose, namely, in their application as design principles and guidelines in the development of new applications. A further effect – in future redesign/upgrade of Info3Net – is that the problems identified can be corrected and enhancements added, as far as possible within the parameters of WebCT™.

- **Second subquestion:** *"To what extent do the findings of heuristic evaluation by experts and survey evaluation among learners correspond?"*

This subquestion was answered in Chapter 7. It was found that, in this comparative case study, the findings of heuristic evaluation by experts correspond closely to those of survey evaluation amongst learners, especially in identifying major problems. This occurred despite the fact that there were 61 learner evaluators and only four expert evaluators.

What can therefore be concluded in response to the **primary research question** *"To what extent can heuristic evaluation identify usability problems of web-based e-learning applications in a tertiary institution?"*

The answer to the second subquestion indicates that heuristic evaluation can reliably be used in identifying problems in web-based e-learning applications in a tertiary institution, provided that the evaluation is based on sound heuristics and that a competent and complementary group of expert evaluators is used. HE was found to be an appropriate, effective and sufficient usability method for the evaluation of an e-learning application. It identified a high percentage of usability problems, and is known to be easy and cost effective to use, in contrast with other methods that are more difficult to apply, time consuming and expensive. Evaluation of e-learning applications is important, however, many educators and courseware developers pay insufficient attention to usability, because they may not be trained to do so, and may have insufficient resources to perform adequate evaluations, as stated in Section 1.1. The findings of this study show that HE is a suitable approach to address these issues. In addition, this study suggests that for a comprehensive usability evaluation of web-based e-learning applications, heuristic evaluation should, ideally, be supplemented by methods where users directly identify or experience usability or learning problems. This is in line with proposals in a recent study by Ardito et al (2006:274), who state that reliable evaluation can be achieved by systematically combining HE with user-based methods. HE can, however, be used as a stand-alone approach.

8.4 Further Research

Recommendations for further research include the following:

- Using the criteria applied in this case study to evaluate other web-based e-learning courses in tertiary institutions.
- Determining which criteria would be most suitable to apply for evaluation by educators only and evaluation by learners only.
- Investigating application of the heuristics generated in this study as guidelines in the design stages of the web-based e-learning applications, whether such applications are developed using a course management system such as WebCT™ or not.
- Investigating how effectively educators without any HCI experience, could apply the evaluation criteria.
- Re-designing Info3Net in an action research approach, to solve many of the problems identified. The application could be re-evaluated to determine the impact of the changes.

8.5 Conclusion

The main purpose of this study was to determine the value and effectiveness of heuristic evaluation, but the research also makes a major contribution in the form of the set of criteria and sub-criteria synthesised. This proposed set of criteria can be used in usability evaluations of e-learning applications.

A web-based e-learning application was developed for supplementary teaching and learning and for evaluation. Two approaches were used in an evaluation case study. One approach, survey evaluation, involved the end users of the application i.e. the learners, and another method, heuristic evaluation, was performed by a set of a small number (four) of expert evaluators. There was a high correspondence between the two sets of results. This shows that HE can reliably be used to identify usability problems of web-based e-learning applications in a tertiary institution. The present researcher thus recommends the HE method as the best choice for usability evaluation of such applications.

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Appendix A: Learner Survey Documents

Appendix A-1: Questionnaire

Questionnaire for Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Note: all the information you provide in this questionnaire is confidential and will only be used for research purposes.

Background Information

Surname____________________________ Initials ______________________

Student number_____________________ Gender ______________________

Age ______________________________ Campus _____________________

Year of study (1, 2, 3)________________

Qualification for which you are registered ____________________________________

Specialization, if any (for example, Web & Applications Development)

____

Please put a cross (X) in the appropriate block(s).

a. For which period have you used computers <u>in the home</u> during your childhood? (Choose one option only)

From a very young age	Through my high school years	Only by the end of my high school years.	Never during my school years

b. What was your exposure to computers at school? i.e. During which period before tertiary education, were you using computers? (Choose one option only)

Primary school only	High school only	Both primary and high school	Never exposed to computers in school

c. There is a subject called Computer Studies at high school. Did you take this as a subject at matric level?

Yes	No

d. Computers in the workplace (Choose one option only)

I have been in full-time employment and worked with a computer in the workplace.	I have been in part-time employment and worked with a computer in the workplace.	I have been in full- or part-time employment, but I did not use a computer in the workplace.	I have not yet been employed, either full- or part-time.

e. Do you have access to a computer at home?

Yes	No

f. Before I started Information Systems 3, I was familiar with (Can choose more than one option)

Word processing (e.g. MS Word^{TM})	Spreadsheets (e.g. Excel^{TM})	Databases (e.g. Access^{TM})	Others – please name	None of them

g.1 Before you started this course had you worked with WebCT^{TM}?

Yes	No

g.2 If your answer to the above question is Yes, for how long had you worked with WebCT^{TM}? __________ years and __________ months.

h.1 Before you started this course, had you worked with any other e-learning application (s)?

Yes	No

h.2 If your answer to the above question is Yes, for how long had you worked with the other e-learning application (s) __________ years and __________ months.

h.3 If the answer to the h.1 was Yes, what is (are) the name (s) of the other e-learning application (s) you used before? ____

i.1 Apart from Information Systems 3, are you using WebCT^{TM} for any other subject (s) this year at Walter Sisulu University (WSU)?

Yes	No

i.2 If the answer to the above question is Yes, list the subject(s) below. Use the subject codes if you remember them. If you do not, fill in the name itself. (Do not include Information Systems 3).

____

j. Do you stay on- or off-campus? i.e. are you a resident, staying on the campus, or non-resident of WSU?

On (Resident)	Off (Non-resident)

k. Do you ever use the site off campus? i.e. use the site when you are not on the university campus, for example, at home or Internet café.

Yes	No

l. Is the site is accessible off-campus?

Yes	No	I do not know

m. How do you use computers? (Can choose more than one option)

I use computers to study	I use computers at work	Others – specify

n. For how long have you used computers? __________ years and __________ months.

o. The computers at WSU use Microsoft Internet Explorer^{TM}, Version 6, Web browser. Which other Web browsers, apart from Internet Explorer^{TM}, have you ever used? (Can use both blocks)

Netscape	Others – specify

p. For how long have you used the Internet? __________ years and __________ months.

q. For how long have you used an Intranet, such as the one used by this institution?

__________ years and __________ months.

r. How would you classify yourself?

As a *novice* user, since I have not used this system or a similar system before	As an *expert* user, since I am experienced and comfortable with using the system

E-Learning application evaluation

*You are **highly encouraged** to write down any **problems** you find in relation to a particular section in the space provided at the end of the section. If what you want to write cannot fit into that space, you may use the extra space provided, in form of a table, on the last page of this questionnaire.*

Category 1: General interface design

1 **Visibility of system status**

1.1 The system keeps me informed through feedback about what is going on.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

1.2 I understand what the feedback means.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

1.3 I get the feedback within reasonable time.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

1.4 For every action I make, I can see or hear the results of that action.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

1.5 The system does not react in a manner that surprises me and it does not do anything unexpected.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

2 **Match between the system and the real world i.e. match between designer model and learner model**

2.1 The language used is natural, since the terms, phrases, and concepts are similar to those used in my day-to-day or study environment.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2.2 I am not confused by the use of terms.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2.3 I am not confused by the way symbols, icons, or images are used.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2.4 There is no jargon used ('jargon' means words, acronyms or expressions that are developed and used by a group of people).

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2.5 The metaphors used correspond to real-world objects or concepts, for example, the icon for saving looks like a floppy disk.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

2.6 Information is arranged in a natural and logical order.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

3 **User control and freedom**

3.1 I control the system, rather than it controlling me.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

3.2 The system works the way I want it to work.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

3.3 Each page has all the required navigation buttons or hyperlink (link), such as *previous* (back) *next* and *home*.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

3.4 When I make a mistake I can choose to exit (close) the system, using a clearly marked Emergency Exit button.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

4 **Consistency and adherence to standards**

4.1 The same convention (standard, or the way things are arranged and done) is used throughout the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.2 It is easy to understand the convention used throughout the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.3 The convention used is similar to the ones in other systems I am used to.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.4 Same words, phrases, situations, or actions refer to the same thing throughout the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.5 Colours are used in a consistent manner (same way) throughout the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.6 Graphics, icons and images are consistently used throughout the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.7 There is consistency in the screen layouts.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.8 There is consistency in the use of menus.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.9 There is consistency in use of font types and sizes.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

4.10 Links to pages are consistent with the titles of the pages they link to.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

5 **Error prevention, specifically prevention of peripheral usability-related errors**

5.1 The system supports me in such a way that it is not easy to make serous mistakes.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

5.2 Whenever a mistake is made an error message is given.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

5.3 The system uses a graphical user interface (such as lists, dropdown, hyper-linked or icon-driven interfaces) that can be clicked on by a mouse, instead of command-driven ones, where commands have to be typed in using a keyboard.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

5.4 I am requested to confirm my entry before carrying out a ‘potentially dangerous’ action such as deleting.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

5.5 I find it easy to enter information in the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

6 **Recognition rather than recall**

6.1 Instructions on how to use the system are visible.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

6.2 There is an obvious relationship between controls and their actions.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

6.3 Objects to use, such as graphics on tools bars, are visible.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

6.4 Options to be selected, such as menus, are easy to recognise.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

6.5 When working on a task, I do not need to recall (remember) information from another task.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

7 **Flexibility and efficiency of use**

7.1 The site caters for different levels of users, from novice to experts.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

7.2 Shortcuts or accelerators, in form of abbreviations, special keys, hidden commands or macros, are available for expert users.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

7.3 The site guides novice users sufficiently.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

7.4 There is an option to use the keyboard alone to perform tasks.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

7.5 The system is flexible enough to enable users to adjust settings to suit them, ie customise the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

8 **Authenticity and minimalism in design**

8.1 Pages contain the required information.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

8.2 The information on each page is not too much to confuse or distract me.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

8.3 There are no excessive use of graphics and images on the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

8.4 Dialog boxes provide adequate information for performing tasks.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

8.5 Dropdown lists and menus have the required options to choose from.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

9 **Recognition, diagnosis, and recovery from errors**

9.1 Error messages are expressed in plain language.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9.2 Error messages indicate precisely what the problem is.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9.3 Each message gives a procedure to fix the error.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9.4 The procedure to fix the error is specific, quick and efficient.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9.5 If a typed command (data) results in an error, I do not have to retype the entire command, but rather repair only the faulty part.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

9.6 The site provides for easy reversal of action where possible, for example, by providing both Undo and Redo.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

10 **Help and documentation**

10.1 I find the help facilities – such as online help and the glossary – useful.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

10.2 The help facilities are easy to use.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

10.3 I find it easy to search for required help.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

10.4 Links to other resources are helpful.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

Category 2: Website-specific design

11 **Simplicity of site navigation, organisation and structure**

11.1 I always know where I am and which options to go to next, i.e. what I have completed and what is still to be done.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.2 There is no need to have the Course Menu since there is a Course Map which serves the same purpose.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.3 Site links always point to the correct documents or pages.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.4 I would like to have links to sections inside the same page.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.5 The colours for links are consistent with Web conventions i.e. non-visited links blue and visited ones green or purple.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.6 Related information is placed together.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.7 Important information is placed at the top of a page.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

11.8 Scrolling is minimised, i.e. I do not have to scroll many pages to find required information.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

12 **Relevance of site content for learning**

12.1 The content keeps me engaged.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

12.2 The content is relevant to what is to be learned.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

12.3 The content is at the appropriate level of my understanding.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

12.4 It is clear which materials are copyrighted and which are not.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

12.5 The material on the site has no racial or gender biases.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

12.6 I like to view records of my site activities, such as visits made on each page.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

Category 3: Learner-centred instructional design heuristics

13 **Clarity of goals, objectives and outcomes**

13.1 I know the goals before each learning encounter.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

13.2 Learning outcomes are communicated to me in advance, before the beginning of the encounter.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

13.3 I find course syllabus useful.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

13.4 I get up-to-date information on the notice board.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

13.5 The calendar provides me with useful information.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

14 **Collaborative learning**

14.1 I like a site that has facilities that encourage group activities such as teamwork, group project and collaborative problem solving.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.2 Collaboration with other learners, initiated or supported by the system, enables me to learn something.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.3 When collaborating with other learners, I would like the lecturer to act as a facilitator, guide, coach or mentor, but not as controller.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.4 When I collaborate with the lecturer, I would like the lecturer to act as a partner, but not as a controller.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.5 Although I have e-mail facilities provided by the institution I still need to have e-mail facilities within the application.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.6 I like to have an academic discussion forum with other learners using discussion facilities on the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

14.7 I like to have an academic discussion forum with the lecturer using discussion facilities on the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

15 **Appropriateness of the level of learner control**

15.1 As an individual I can decide what to learn and what to leave out, within the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

15.2 When I use the site, I feel that I am in control of my own learning.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

15.3 I feel a sense of ownership of this site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

15.4 I can use my own path to find what I want to learn within the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

15.5 From the site I like to access the Internet to find my own learning material.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

16 **Support for personally significant approaches to learning**

16.1 The site supports different strategies for learning.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

16.2 The site is used in combination with other mediums of instruction to support learning.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

16.3 The site enables me to plan, evaluate and question my learning abilities.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

16.4 The site encourages me to improve my skills.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

16.5 The site encourages me to apply learned skills into practical/real-world situations.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

17 **Cognitive error recognition, diagnosis and recovery**

17.1 When I get wrong answers to the problems provided on the system, the solutions offered by the system help me to learn.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

17.2 I believe that people learn by their mistakes.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

17.3 The system recognises that as a learner, I may have wrong concepts about things, and that trying to correct these is part of learning.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

18 **Feedback, guidance and assessment**

18.1 The system provides feedback regarding my activities and knowledge.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

18.2 I appreciate the guidance in form of sample questions and their solutions.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

18.3 I appreciate quantitative feedback in terms of grading my activities.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

19 **Meaningful context**

19.1 Knowledge is presented within a meaningful context that helps me to learn.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

19.2 Knowledge is presented in a way that is authentic i.e. corresponds to how things are in practice.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

19.3 Authentic, contextualised tasks (tasks that relate to the real-world ones) are undertaken, rather than abstract instruction (purely theoretical models).

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

19.4 The symbolic representations used are easy to understand and the symbols used are meaningful within the context of the learning task.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

20 **Motivation, creativity and active learning**

20.1 The application provides intrinsic (self) motivation that makes me want to learn.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.2 The grades and other incentives that I get act as extrinsic (external) motivation to learn and accomplish institutional requirements.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.3 The application engages me.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.4 The application holds my attention.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.5 I am attracted to the site due to its content and interactions.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.6 I like the look-and-feel of this site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.7 I prefer to have activities, such as quizzes/tests, that are subdivided or chunked so that they do not take too long.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.8 I enjoy the quizzes/tests on the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

20.9 I enjoy doing self-tests on the site.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

Write down any particular problem (s) you found in the system, in relation to this section, using the space below. Use the last page if this space is full.

Conclusion

a. I found it easy to use the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

b. The system is fast to work with.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

c. The system performed tasks properly.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

d. Once I learnt how to use the system it was easy to use it the next time.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

e. I was satisfied with the system.

Strongly agree	Agree	Maybe	Disagree	Strongly disagree

f. How well did the site work as a supplement to class instruction?

Very good	Good	Adequate	Poor	Very poor

g. I would rather learn using

the WebCT™ site only	the class only	both the class and the WebCT™ site

h. What is your overall rating of this site?

Very good	Good	Adequate	Poor	Very poor

i. What attracted you most to this site?

____

j. What did you like most about this site?

____

k. What did you like least about this site?

____

l. Use the space that follows to fill in at *least five* problems that you found most critical in the system.

m. Please feel free to comment on any features of this site, in the space provided below, such as, overall impression, features you like best, features you like least, and what features you would like to see in this system in future.

Space for more problems

Use this page if there are problems that could not fit in the space provided for a particular section. Fill in the number of the section in the left column and write the problem(s) using the right column.

Number e.g. 2	**Other problem (s) found**

If you are interested in the results of this evaluation please provide your e-mail address here: ______________________________________

Thank you for your participation

Appendix A-2: Covering Letter

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Introduction and background information

Dear student,

I am a lecturer in the department of Computer Studies at Walter Sisulu University (WSU). My name is Sam Ssemugabi. I am currently studying towards a Masters degree in Information Systems with the University of South Africa. As part of the studies, I am doing a research project concerned with the **usability of e-learning applications**. When you, as a student, use an e-learning application, as you do in Information Systems 3, you want the system to help you to learn. The system should be easy to use. At the same time, it should support learning. This research aims to make some contribution in developing usable e-learning applications. Your contribution will assist me in this research.

I am requesting you to fill in the questionnaire with care and sincerity. It will take about 1 to 1½ hours to complete. Please do not give responses for the sake of pleasing me, instead give your sincere personal observations or opinions. In fact the main aim of this evaluation is for you to identify **problems** that the system has. Because of this, negative, but sincere, criticism is welcome. Remember you are evaluating the system – not me. Do not rush through the questionnaire. Take your time.

Please write the problems you find in the spaces provided, for problems, in the questionnaire. These could be facts, opinions or personal preferences. Be specific. Examples of how to set out your problems are:

- The spelling of 'dtabase' in Quiz 2C is not correct.
- I do not like the background colour of the main menu.
- Quizzes do not help me to learn.
- I would like to have a section on frequently asked questions (FAQs), but it is not available.
- When I am on the 'Communicate' page, I cannot see a link to go back to the main menu.

[*I just made these up; use the system to determine the real problems]*

How to perform the evaluation
As you go through the steps, look out for any problems with the system that may make it difficult to use or make it difficult for you to learn. If you encounter such problems, they will be the kind of issues you will describe in the questionnaire when completing the open block sections at the end. Please do not rush over these parts – your contributions in these sections are very important.

Step 1: When you login to the system, take a few minutes to refamiliarise yourself with the system if you have forgotten some of its features. Browse the system.

Step 2: Read the section on "The Relational database model" under Course Material → Databases → Table of Contents. Read both the objectives and overview. This is done in preparation for a quiz you are going to do that will need this information as well as your general knowledge on databases.

Step 3: Do the quiz named Quiz 2C. You will be given the password for the quiz. This and the last step are to remind ourselves of some of the ways we have used the system before.

Step 4: Sign the Student consent form which is attached to this document.

Step 5: Do the system evaluation using the questionnaire. Apart from the problems you may have observed in Step 1 to 3, please feel free to include any other problems you have encountered with this system before. However be specific. As you do the evaluation, you can check back on certain sections of the system, including "The Relational database model" and Quiz 2C to identify problems.

Step 6: Hand the evaluation back to me, as well as this document with the attached consent form.

All information provided by you is treated as being confidential and will only be used for research purposes. If you are interested in the results of this evaluation please include an e-mail address at the end of the questionnaire.

Thank you very much for participating in this evaluation exercise.

Sam Ssemugabi (xxx@yyy.com)

Appendix A-3: Consent Form

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Student consent form

I ______________________________________ (First name and Surname) and student number _____________, a student at Walter Sisulu University state that I have not been put under any pressure to participate in this evaluation exercise, and have willingly participated in it.

I realise that the findings of the evaluation will be used for research purposes and that the findings will be published.

Signed ________________________ date __________________________

Appendix A-4: Questionnaire Rating Summary Results

Statement *as in Appendix A-1*	**Strongly agree (Likert 1)**		**Agree (2)**		**Maybe (3)**		**Disagree (4)**		**Strongly disagree (5)**		**Average rating**
	f	***%***	***f***	***%***	***f***	***%***	***f***	***%***	***f***	***%***	
1.1	11	19	41	69	5	8	2	3	0	0	**2.1**
1.2	17	28	33	55	10	17	0	0	0	0	**1.9**
1.3	5	8	32	53	13	22	10	17	0	0	**2.5**
1.4	8	13	36	60	9	15	7	12	0	0	**2.3**
1.5	11	19	27	47	9	16	10	18	0	0	**2.3**
2.1	13	21	35	57	5	8	8	13	0	0	**2.1**
2.2	6	10	38	63	10	17	6	10	0	0	**2.3**
2.3	7	11	30	49	14	23	8	13	2	3	**2.5**
2.4	5	8	19	31	20	33	15	25	2	3	**2.8**
2.5	12	20	21	34	15	25	11	18	2	3	**2.5**
2.6	11	18	36	59	10	16	4	7	0	0	**2.1**
3.1	12	20	37	61	8	13	4	7	0	0	**2.1**
3.2	3	5	42	69	11	18	5	8	0	0	**2.3**
3.3	14	24	21	36	5	8	17	29	2	3	**2.5**
3.4	7	12	14	24	11	19	22	37	5	8	**3.1**
4.1	14	23	28	47	12	20	5	8	1	2	**2.2**
4.2	5	8	38	62	12	20	6	10	0	0	**2.3**
4.3	3	5	31	51	21	34	6	10	0	0	**2.5**
4.4	4	7	31	53	14	24	10	17	0	0	**2.5**
4.5	15	25	29	48	5	8	10	16	2	3	**2.3**
4.6	12	20	34	56	9	15	6	10	0	0	**2.1**
4.7	16	27	27	45	11	18	6	10	0	0	**2.1**
4.8	14	23	36	60	6	10	3	5	1	2	**2.0**
4.9	15	25	33	55	7	12	4	7	1	2	**2.1**
4.10	19	32	31	53	6	10	1	2	2	3	**1.9**
5.1	13	22	36	60	9	15	2	3	0	0	**2.0**
5.2	11	18	29	48	10	16	8	13	3	5	**2.4**
5.3	25	42	26	43	6	10	3	5	0	0	**1.8**
5.4	17	29	22	37	13	22	7	12	0	0	**2.2**
5.5	17	29	29	49	5	8	7	12	1	2	**2.1**
6.1	15	25	30	50	9	15	6	10	0	0	**2.1**
6.2	9	15	38	64	9	15	2	3	1	2	**2.1**

6.3	9	16	42	72	6	10	1	2	0	0	**2.0**
6.4	10	17	37	63	9	15	3	5	0	0	**2.1**
6.5	5	9	25	43	16	28	11	19	1	2	**2.6**
7.1	13	22	22	37	13	22	9	15	2	3	**2.4**
7.2	9	16	19	33	16	28	13	22	1	2	**2.6**
7.3	8	14	24	42	18	32	7	12	0	0	**2.4**
7.4	4	7	16	28	17	29	18	31	3	5	**3.0**
7.5	5	8	16	27	14	23	22	37	3	5	**3.0**
8.1	10	16	39	64	10	16	1	2	1	2	**2.1**
8.2	15	25	37	61	5	8	3	5	1	2	**2.0**
8.3	7	11	34	56	17	28	3	5	0	0	**2.3**
8.4	5	8	31	53	17	29	6	10	0	0	**2.4**
8.5	11	18	43	70	7	11	0	0	0	0	**1.9**
9.1	16	27	29	48	11	18	4	7	0	0	**2.1**
9.2	11	19	28	47	16	27	4	7	0	0	**2.2**
9.3	3	5	20	36	16	29	16	29	1	2	**2.9**
9.4	4	7	16	28	23	40	13	22	2	3	**2.9**
9.5	7	12	11	19	29	49	9	15	3	5	**2.8**
9.6	11	18	14	23	11	18	20	33	4	7	**2.9**
10.1	0	0	3	43	2	29	1	14	1	14	**3.0**
10.2	0	0	4	57	1	14	2	29	0	0	**2.7**
10.3	0	0	2	29	2	29	3	43	0	0	**3.1**
10.4	1	14	5	71	0	0	1	14	0	0	**2.1**
11.1	20	33	27	45	6	10	7	12	0	0	**2.0**
11.2	10	17	25	42	11	18	10	17	4	7	**2.6**
11.3	16	27	37	62	4	7	3	5	0	0	**1.9**
11.4	12	21	24	43	12	21	6	11	2	4	**2.3**
11.5	12	21	19	33	10	18	11	19	5	9	**2.6**
11.6	12	21	34	59	11	19	1	2	0	0	**2.0**
11.7	9	16	25	45	15	27	7	13	0	0	**2.4**
11.8	11	19	35	59	7	12	5	8	1	2	**2.2**
12.1	8	14	36	62	7	12	7	12	0	0	**2.2**
12.2	14	24	40	68	5	8	0	0	0	0	**1.8**
12.3	13	22	38	64	5	8	3	5	0	0	**2.0**
12.4	4	7	24	41	19	33	11	19	0	0	**2.6**
12.5	32	54	22	37	4	7	1	2	0	0	**1.6**
12.6	16	27	24	41	14	24	4	7	1	2	**2.2**
13.1	9	16	29	50	9	16	11	19	0	0	**2.4**

13.2	13	22	28	48	6	10	11	19	0	0	**2.3**
13.3	24	41	31	53	3	5	1	2	0	0	**1.7**
13.4	14	25	20	35	10	18	9	16	4	7	**2.5**
13.5	12	21	18	32	14	25	10	18	3	5	**2.5**
14.1	18	31	33	56	4	7	3	5	1	2	**1.9**
14.2	17	28	29	48	12	20	2	3	1	2	**2.0**
14.3	24	39	31	51	1	2	4	7	1	2	**1.8**
14.4	25	41	28	46	4	7	4	7	0	0	**1.8**
14.5	5	8	22	37	11	19	15	25	6	10	**2.8**
14.6	13	22	35	59	10	17	1	2	0	0	**2.0**
14.7	17	29	25	42	15	25	2	3	0	0	**2.0**
15.1	14	23	36	60	6	10	3	5	1	2	**2.0**
15.2	16	27	31	53	9	15	3	5	0	0	**2.0**
15.3	9	15	28	47	16	27	6	10	1	2	**2.4**
15.4	4	7	22	37	17	28	15	25	2	3	**2.8**
15.5	10	17	27	47	13	22	6	10	2	3	**2.4**
16.1	9	15	34	57	15	25	2	3	0	0	**2.2**
16.2	2	3	39	65	15	25	4	7	0	0	**2.4**
16.3	9	15	36	60	10	17	4	7	1	2	**2.2**
16.4	20	33	31	52	4	7	5	8	0	0	**1.9**
16.5	16	27	25	42	13	22	6	10	0	0	**2.2**
17.1	17	28	28	47	12	20	3	5	0	0	**2.0**
17.2	36	59	23	38	2	3	0	0	0	0	**1.4**
17.3	24	40	27	45	6	10	3	5	0	0	**1.8**
18.1	14	23	35	57	9	15	3	5	0	0	**2.0**
18.2	24	39	29	48	6	10	2	3	0	0	**1.8**
18.3	19	32	37	62	3	5	1	2	0	0	**1.8**
19.1	12	20	43	73	4	7	0	0	0	0	**1.9**
19.2	6	10	44	75	8	14	1	2	0	0	**2.1**
19.3	7	12	23	39	23	39	6	10	0	0	**2.5**
19.4	7	12	29	50	15	26	7	12	0	0	**2.4**
20.1	14	24	38	64	5	8	2	3	0	0	**1.9**
20.2	11	18	33	55	14	23	2	3	0	0	**2.1**
20.3	13	22	32	54	12	20	2	3	0	0	**2.1**
20.4	17	28	32	53	8	13	3	5	0	0	**2.0**
20.5	13	22	30	50	14	23	3	5	0	0	**2.1**
20.6	11	19	31	53	12	20	5	8	0	0	**2.2**
20.7	28	47	25	42	1	2	6	10	0	0	**1.8**

20.8	30	50	23	38	3	5	4	7	0	0	**1.7**
20.9	29	48	25	42	2	3	3	5	1	2	**1.7**
Mean											**2.3**
Standard deviation											**0.4**
Conclusion Section											
a	23	38	32	52	5	8	1	2	0	0	**1.7**
b	14	23	31	51	7	11	8	13	1	2	**2.2**
c	12	20	42	69	6	10	1	2	0	0	**1.9**
d	20	33	38	62	3	5	0	0	0	0	**1.7**
e	12	20	36	59	10	16	3	5	0	0	**2.1**
f	14	23	37	61	8	13	2	3	0	0	**2.0**
g	6	10	3	5	52	85					
h	13	21	43	70	3	5	2	3	0	0	**1.9**

Appendix A-5: The Original Set of 64 Problems Identified by the Learners

	Problem	
	Category 1: General interface design heuristics	***f***
1	**Visibility of system status**	
	1.1 When doing a quiz/test, if an answer has already been saved and then if one changes his/her mind and selects another answer and clicks the Save Answer button, there should be feedback by the system to confirm that the later answer is the one accepted.	1
	1.2 The time allocated to do a quiz/test should be known before, instead of after the user clicks on the button to start the test.	1
2	**Match between the system and the real world i.e. match between designer model and user model**	
	2.1 Symbols are not meaningful.	8
	2.2 Some terminologies are unfamiliar.	5
	2.3 Calendar should be called a Diary	1
3	**User control and freedom**	
	3.1 There are no facilities for Undo and Redo.	16
	3.2 The system is slow to respond.	13
	3.3 There is no system exit button.	12
	3.4 When doing a quiz/test, if the test is submitted before the time expires, one should have a chance to change answers within the time limit.	7
	3.5 It is not easy to print site content.	1
	3.6 There is no ‘Print version’ of the notes in the Table of Contents.	1
4	**Consistency and adherence to standards**	
	4.1 Same symbols/icons represent different things.	7

	4.2 Background colour is white on some pages and blue on others	6
	4.3 In order to be consistent, the format for the self test should be the same as that of the quiz/test.	2
	4.4 All pages should have a title, but the Introduction page does not.	1
	4.5 On the Course Material page, the size and layout of the 'Databases' icon should be consistent with the other icons by not having a different size and shape.	1
5	**Error prevention, specifically prevention of peripheral usability-related errors**	
	5.1 The system does not always give error messages to prevent errors from occurring.	3
	5.2 When doing a quiz/test, the system should inform the user immediately he/she tries to move away from a question, that the answer selected is not saved. Instead, the user is informed at the end of the quiz/test.	3
	5.3 Whatever is entered into the system is accepted. There are no ways to avoid erroneous/meaningless entries.	2
6	**Recognition rather than recall**	
	6.1 Instructions on how to perform some tasks are not visible.	1
	6.2 On the View Results page for multiple choice questions for quizzes/tests, the row in which the correct answer is located should be bold so that it is easily recognisable.	1
	6.3 There is no obvious relationship between controls and their actions.	1
	6.4 Some links, WebCT™ default links, such as Resume Course, are difficult to recognise since they are labelled in small fonts.	1
7	**Flexibility and efficiency of use**	
	7.1 It is not easy to navigate the system using the keyboard only.	7
	7.2 The system cannot be customised.	5
	7.3 There are no shortcuts provided.	4
	7.4 The system is not flexible "you do what is exactly required and leave it that way"	3
	7.5 The system does not cater for novice users.	2

	7.6 It is not easy to use the Help System. For example, the structure of the WebCT™ Help System is confusing.	1
8	**Authenticity and minimalism in design**	
	8.1 Notices on the Notice Board should show the dates when they were posted.	10
	8.2 When starting a quiz /test, there is too much info in one window.	2
	8.3 The use of a three-window design for the Table of Contents makes it difficult to read the content.	1
	8.4 Instead of saving answers one-by-one, there should be one Save Answers button for the entire quiz/test, to minimise time loss.	1
9	**Recognition, diagnosis, and recovery from errors**	
	9.1 The error messages given are not helpful, for they do not provide any instructions to fix errors.	7
	9.2 If a typed command (data) results in an error message, one has got to retype the entire command instead of repairing the faulty part only.	3
	9.3 When the wrong password is entered for a quiz/test, the error message should be in a text box instead of appearing on the screen where it is entered.	1
10	**Help and documentation**	
	10.1 It is not easy to search for information on the site.	3
	10.2 The Help System is not appropriate for the user, since it refers to issues more relevant to the designer than to the learner.	2
	10.3 There is no FAQ section.	1
	10.4 There is no section on how to use the site.	1
	Category 2: Website-specific design (educational websites) heuristics	***f***
11	**Simplicity of site navigation, organisation and structure**	
	11.1 There is no Forward/Next button.	10
	11.2 There is no Back button so it is difficult to link back to the previous page.	8

	11.3 On the Home page, the options should be arranged in a more natural order.	2
	11.4 The Course menu should show where the user is.	1
	11.5 Visited links do not show this by colour.	1
	11.6 There should be links to sections inside the same page to minimise scrolling.	1
	11.7 The colours of the links are not consistent with Web conventions, i.e. non-visited links are not blue and visited ones are not green or purple.	1
	11.8 The link to the library under Useful Links should link to the relevant materials in the library, but not to the library's search section.	1
	11.9 There should be Forward and Back buttons within the site apart from those on the browser.	1
	Category 3: Learner-centred instructional design heuristics	***f***
13	**Clarity of goals, objectives and outcomes**	
	13.1 Calendar information is not sufficient.	6
	13.2 Course goals are not clear.	3
	13.3 Links on main page should be accompanied by brief explanations of what is found in the sections to which they are linked.	2
14	**Collaborative learning**	
	14.1 Although facilities exist for learner-learner and learner-teacher interactions, there are no procedures in place to encourage their use.	3
	14.2 There are no facilities for synchronous communication such as video conferencing.	1
18	**Feedback, guidance and assessment**	
	18.1 Glossary is not sufficient. More terms/phrases need to be defined.	3
	18.2 Each unit must have its self test.	2
	18.3 In Question 1 of the quiz/test done, the word 'metadata' is shown as the correct answer, but 'Metadata' is marked wrong whereas learners were not informed that the system is case sensitive.	2
	18.4 The feedback provided via the system about the learners' activities (such as tests	2

	and assignments) is limited.	
	18.5 The guidance provided via the system about the learners' activities is limited. For example, diagrams and pictures should be used to illustrate learning concepts.	2
	18.6 Class lecture slides/notes, and quiz/test and assignment solutions should be available on the site.	3
	18.7 Diagrams and pictures should be used to illustrate learning concepts.	2
	18.8 There should be links to previous years' learning material.	1
20	**Motivation, creativity and active learning**	
	20.1 There are inadequate activities to attract learners to the site.	3
	20.2 More content is required to encourage learners to compare, analyse or classify information so as to promote active learning and intuition	2

Appendix B: Heuristic Evaluation Documents

Appendix B-1: Heuristics for Expert Evaluators

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Heuristic evaluation criteria

Category 1: General interface design heuristics	
1	**Visibility of system status** • The website keeps the user informed about what is going on through constructive, appropriate and timely feedback. • The system responds to actions initiated by the user. There are no surprise actions by the site or tedious sequences of data entries.
2	**Match between the system and the real world i.e. match between designer model and user model** • Language usage such as terms, phrases, symbols, and concepts, is similar to that used by the users in their day-to-day environment. • The metaphor usage corresponds to that of real-world objects or concepts. For example, understandable and meaningful symbolic representations are used to ensure that the symbols, icons and names used are intuitive within the context of the performed task. • Information is arranged in a natural and logical order.
3	**User control and freedom** • Users control the system. • Users can exit the system at any time even when they have made mistakes. • There are facilities for Undo and Redo.
4	**Consistency and adherence to standards** • The same concepts, words, situations, or actions refer to the same thing. • Common platform standards are followed.

5	**Error prevention, specifically prevention of peripheral usability-related errors** • The system is designed such that the users cannot easily make serious errors. • When a user makes an error, the application gives an error message.
6	**Recognition rather than recall** • Objects to be manipulated, options for selection, and actions to be taken are visible. • The user does not need to recall information from one part of a dialogue to another. • Instructions on how to use the system are visible or easily retrievable whenever appropriate. • Displays are simple and multiple page displays are minimised.
7	**Flexibility and efficiency of use** • The site caters for different levels of users, from novice to experts. • Shortcuts or accelerators, unseen by the novice users, are provided to speed up interaction and task completion by frequent users. • The system is flexible enough to enable users to adjust settings to suit themselves, i.e. customise the system.
8	**Authenticity and minimalism in design** • Site dialogues do not contain irrelevant or rarely needed information, which could distract users as they perform tasks.
9	**Recognition, diagnosis, and recovery from errors** • Error messages are expressed in plain language. • Error messages indicate precisely what the problem is and give quick, simple, constructive, specific instructions for recovery. • If a typed command results in an error, the user does not have to retype the entire command, but rather repair only the faulty part.
10	**Help and documentation** • The site has a help facility and other documentation to support the user's needs. • The information in these documents is easy to search, focused on the user's task and lists concrete steps to be carried out to accomplish a task.

<table>
<tr><th colspan="2">Category 2: Website-specific design (educational websites) heuristics</th></tr>
<tr><td>11</td><td>Simplicity of site navigation, organisation and structure
The site has a simple navigational structure.
Users should know where they are and have options of where to go next, i.e. they should be aware of what has been completed and what is still to be done.
The navigational options are limited so as not to overwhelm the user.
Related information is placed together.
Information is organised hierarchically, starting with general information then specific.
Common browser standards are followed.
Each page has all the required navigation buttons or hyperlinks (links), such as previous (back) next and home.</td></tr>
<tr><th colspan="2">Category 3: Learner-centred instructional design heuristics</th></tr>
<tr><td>13</td><td>Clarity of goals, objectives and outcomes
There are clear goals, objectives and outcomes for learning encounters.
The reason for inclusion of each page or document on the site is clear.</td></tr>
<tr><td>14</td><td>Collaborative learning
Facilities and activities are available that encourage learner-learner and learner-teacher interactions.
There are facilities for both asynchronous and synchronous communication, such as e-mail, discussion forums and chat rooms.</td></tr>
<tr><td>18</td><td>Feedback, guidance and assessment
Apart from the interface-feedback by the system, as described in Criterion 1, learners give and receive prompt and frequent feedback about their activities and the knowledge being constructed.
Learners are guided as they perform tasks.
Quantitative feedback, for example, in terms of grading learners’ activities, is given so that learners are aware of their level of performance.</td></tr>
</table>

20	**Motivation, creativity and active learning** • The site has features that motivate learners, and promotes creativity by engaging learners. For example, the activities in the application are situated in practice and will interest and engage learners. • To promote active learning, learners are encouraged to compare, analyse or classify information, or make deductions from it. • In order to attract and retain learners, the application engages them by its content and interaction.

Appendix B-2: Phases of the Heuristics Evaluation

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Phases

1. Read all the documents provided. They include the following:
    i. Phases: use Expert*Eval-Phases* document (this document)
    ii. System and user profiles: use *System&UserProfile* document
    iii. Procedure: use *Eval-Procedure* document
    iv. Consent form: use Expert*Eval-Consent* document
    v. Heuristic evaluation criteria: use Expert*Eval-Heuristics* document

2. Familiarise yourself with the evaluation criteria (heuristics) that you will use. A brief description of each heuristic is given in the table. Note that the word ‘user’ refers to a learner and ‘system’ to the website. The skipped numbers in the table refer to criteria that are specifically for evaluation of content or that deal with issues which can only be answered by the individual learner, but not by you the expert.

3. Please set apart about 2 hours to perform the evaluation. Make sure you have Internet access during that time.

4. Perform the actual evaluation. Use *Eval-Procedure* document provided.

5. E-mail the report to me at xxx@yyy.com.

6. Sign the consent form and fax it to me at Fax no: 123 456 7890.

7. After this initial exercise, a document with a list of the problems identified by all the experts will be sent to you in order to rate the severity of each problem. Rate them and e-mail it back to me.

Thank you very much for participating in this evaluation exercise.

Appendix B-3: System and User Profile

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

System and user profile

System and its use

I developed the Information Systems 3 WebCT™ site at the beginning of this year (2005) to supplement the face-to-face learning/teaching of the course. The structure and all the content and quizzes/tests/self-tests were developed before the learners started using the site. Information System 3 is a third level year subject at WSU that covers Database Systems in the first semester and Project Management in the second. The site was mainly used by learners in the first semester. Apart from their normal paper-based tests, five tests, corresponding to the five units in the table of contents, were done using this system. These tests contributed to the learners' year marks, though at a low weight. Most of these were multiple choice questions. On the day of the learner-evaluation, learners were asked to first read a specific section of the contents and do a quiz. You will be asked to do both activities too. Apart from adding a quiz for you, equivalent to the one they did in their evaluation, the system has not been modified since its evaluation by learners.

The computers used through the year were workstations on the institution's LAN on which the WebCT™ server is connected. These are Pentium™ 4s, with 2.8 GHz processors and 256 RAM. They have 15 inch monitors with a resolution of 1024 by 768 pixels and colour quality of Highest (32) bit. The system can be described as being generally fast, with high quality visual display.

I am the co-ordinator of this subject. I am therefore responsible for all study material made available to the learners, practical exercises, projects, tests, and exams.

Users

There are about 80 learners registered for the subject. They are all third year learners in the final year of the National Diploma in Information Technology. Nearly half of the activities of these learners, since first-year level, involve using computers in the form of laboratory-based practical exercises, projects and presentations. Each of these learners has done at least one subject in programming, database design and basic PC hardware and software. They are comfortable with using Microsoft Windows™ (up to XP) operating system and Microsoft Office™ (Word™, Excel™, PowerPoint™ and Access™ – up to XP) package. They are also comfortable with using web-based systems, using Internet Explorer™, and e-mail, especially GroupWise (client and web-based). The learners can be classified as expert computer users and, as such, no training was given to them on how to use the system, even though it was their first time using WebCT™. However, some instructions were given to them prior to using the system. The learners use the system on campus, since about 60% of them are campus residences and the rest do not have computers at home, and only use computers when on campus. The workstations are accessible to learners even during non-lecture times. The system is accessible on- and off-campus at any time of the day.

Appendix B-4: Procedure for Heuristic Evaluation

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Procedure

1. Go to the WSU WebCT™ site (http://yyy.com) and log in as a student. You will be provided with the user name and ID.

2. Take about 15 minutes browsing the site to familiarise yourself with the system.

3. User Tasks: perform the activities listed to get a feel for the use of the system. Your evaluation will be based on these two activities and some other parts of the system.
    a. *Content*: read the section on 'The Relational database model' under Course Material → Databases → Table of Contents. Read both the *Objectives* and *Overview*.
    b. *Quiz*: do the quiz named Quiz 2C1 under Assessment → Tests and Quizzes. You will be provided with the password for the quiz. Save the answer for each question and submit your answers before the time expires. Click on View Scores to see the score. Click the 1 under Attempts to see the details.

4. List any violations of the heuristics that you identify in the system, i.e. problems that occur (*Ignore other sections in the Table of Contents for Databases and details of any quizzes/tests other than Quiz 2C1, which you have done. However, include any other problems in the other parts of the system*). Please be specific in describing the problem by explaining why it is a problem with respect to the heuristic(s) violated. Each problem should be written out separately. The number in the first column of the table of the heuristics may be used to refer to a particular criterion. You are free to visit any section of the site to identify and describe a problem. Just to make it clear, please evaluate any site component except those inside the content and quizzes/tests that you have been advised to ignore. Concentrate on the user tasks in 3. above and the other parts of the system.

5. Write a report about the problems. Indicate how long it took you to familiarise yourself with the system, and to do the evaluation itself. At the end of the report you may include comments on how you found the evaluation process. For example, problems you found in the system, but that could not be related to any of the heuristics, heuristics that were not clear, overlapping heuristics, setup of the whole expert evaluation exercise, how the evaluation could have been improved, etc.

6. E-mail the report to me at xxx@yyy.com

Thank you very much for participating in this evaluation exercise.

<u>Appendix B-5: Consent Form</u>

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Expert evaluation

<u>Consent form</u>

I ___________________________________working as ___________________________ at ____________________________________ in the department of ____________________ ____________________________ state that I have not been put under any pressure to participate in this evaluation exercise as an expert evaluator, and have willingly involved myself in it.

I realise that the findings of the evaluation will be used for research purposes and that the findings will be published.

Signed ____________________________ date _______________________________

Appendix B-6: The Original Set of 77 Problems Identified by Expert Evaluators

	Problem	Eval
	Category 1: General interface design heuristics	
1	**Visibility of system status**	
	1.1 When doing a quiz/test, if an answer has already been saved and then if one changes his/her mind and selects another answer and clicks the Save Answer button, there should be feedback by the system to confirm that the later answer is the one accepted.	3
	1.2 When submitting a quiz/test, the following message is given in a dialog box “All questions have been answered and all answers have been saved. Do you want to proceed?” with an OK and Cancel button. In this case the cancel option is confusing since it not clear whether it refers to the cancellation of this step or of the whole quiz/test.	3
	1.3 When starting a quiz/test, it is surprising that though the only button on this page is Begin Quiz, when the enter key is used, the system displays the same page, still with the Begin Quiz button, with the exception of the textbox and the instructions for entering the password.	2
	1.4 In rare circumstances, when some of the links on the Course Menu (site index) are clicked on, the message “WebCT^{TM} has not been configured to run with framesets” appears and the Course Menu disappears. This is a surprise action.	4
2	**Match between the system and the real world i.e. match between designer model and user model**	
	2.1 When notes are taken for the first time, the button for saving them should not be labelled ‘Update’.	3
	2.2 ‘My progress’ option should not refer to the number of times different pages have been visited but rather to marks/grades gained or proportion of work covered.	3
	2.3 When doing online assessment, the term ‘Test’ rather than ‘Quiz’ should be used since learners are not familiar with the later.	4
	2.4 Under Discussions, the status of a topic could be ‘Public, Unlocked’. These terms are not familiar to learners.	3
	2.5 In the discussion forum, the use of ‘Title’ and ‘Topic’ is confusing.	3
	2.6 The Calendar object should be called a Diary.	4
	2.7 The options, such as ‘Content module table of contents’, given in the dropdown list on the Search page should match with those on the Course Menu options.	3

	2.8 Symbols such as the icons used on the Home Page are not meaningful.	3
	2.9 The terminology, such as 'Content module' and 'Content page', used by the Help System is unfamiliar to users (learners).	3
	2.10 On the Communicate page, the options should be arranged in alphabetic order i.e. Discussion, Mail and Notice Board, instead of Discussion, Notice Board and Mail, as is the case now.	2
	2.11 The visual layout of the Course Menu should be more natural in that items at the same site level have the same alignment. For example, those on the Home Page (level 1) should have the same alignment.	2
3	**User control and freedom**	
	3.1 There are no facilities for Undo and Redo.	2,3
	3.2 There is no system exit button.	4
	3.3 There is no way to exit the Help System to the main system, apart from closing the Help window.	4
	3.4 Sometimes the system is slow to respond.	4
	3.5 It is not easy to print the Learner Guide and there is no 'Print version' of the notes found in the hyperlinks in the Table of Contents.	1,2,3
4	**Consistency and adherence to standards**	
	4.1 Same symbols/icons represent different things. For example, on the Home Page the icon for Student Resources is the same as that for Assessment.	4
	4.2 On the Course Material page, the size and layout of the 'Databases' icon should be consistent with the other icons by not having a different size and shape.	3
	4.3 In the Learner Guide the spaces between sections should be consistent. Some should not be single and others double.	3
	4.4 In order to be consistent, the format for the self test should be the same as that of the quiz/test. For example, a mark/grade should be allocated as is done with a quiz/test.	2,3,4
5	**Error prevention, specifically prevention of peripheral usability-related errors**	
	5.1 In some cases, there are no ways to avoid erroneous/meaningless entries. For example, in Discussions, whatever is entered as a title or message is accepted.	3
	5.2 The system does not give error messages to prevent errors from occurring.	3

6	**Recognition rather than recall**	
	6.1 When starting a quiz/test, after entering the password, there should be an Enter button next to the textbox for the password instead of the Begin Quiz button which is a number of line spaces down from the textbox.	2
	6.2 When there is a space in a fill-in-the-answer type of question in a quiz/test, it is not clear whether to insert the answer in that space or in the text box given after the question.	3
	6.3 When performing a quiz/test, the error message, for example, when time has elapsed refers to ‘Submit quiz’ but the button used to submit the quiz is labelled Finish.	2
	6.4 On the View Results page for quizzes/tests, ‘Attempt: 1/1’ is confusing since the ‘1/1’ could be mistaken for a score.	3
	6.5 On the Statistics page for quizzes/tests, it is not easy to recognise that the check box on the left must be checked before the statistics for quizzes/tests is given.	4
	6.6 On the Statistics page for quizzes/tests, it is not easy to know when to use the options ‘Summary Statistics’ or ‘Item Statistics’.	4
	6.7 In the Take Notes section, when the View All option is selected, it is difficult to know which notes relate to which section since for each section only the words ‘Objectives’ and ‘Overview’ are listed without showing the name of the main section they belong to.	2,3
	6.8 It is not easy to recognise that by clicking on the Course Menu arrow the Course Menu window disappears or reappears.	1
	6.9 On the Course Menu, the Home Page link should be bold so that it clearly stands out from the rest.	2
	6.10 On the View Results page for multiple choice questions for quizzes/tests, the row in which the correct answer is located should be bold so that it is easily recognisable.	3
7	**Flexibility and efficiency of use**	
	7.1 There are no shortcuts provided.	3,4
	7.2 The system cannot be customised. For example, whereas the three-window design in the Table of Contents can be customised to a two-window one, by clicking on the arrow on the left of Course Menu, it is not possible to customise it to a single window.	1,3,4
	7.3 The system is not flexible in its use.	4
	7.4 The system does not cater for different levels of users.	4
	7.5 When entering date/time values, in order to speed up data entry, the default values should be ‘00’ instead of ‘--’. For example, if the user needs to enter the time as 13h00 in the calendar, he/she should not be forced to select the ‘00’ to replace the ‘--’.	2

	7.6 The Discussions facility is not easy to use.	3
	7.7 It is difficult to perform tasks on the Calendar. For example, after adding an entry to the Calendar, it is not clear how to go back to the main system.	4
	7.8 It is not easy to use the Help System.	4
8	**Authenticity and minimalism in design**	
	8.1 Notices on the Notice Board should show the dates when they were posted.	3
	8.2 The use of a three-window design for the Table of Contents makes it difficult to read the content.	1
	8.3 When starting a quiz /test, there should be one window with instructions on how to do the test followed by another one for entering the password. This would be preferable to clustering all the information on one window.	2
9	**Recognition, diagnosis, and recovery from errors**	
	9.2 The error messages given are not helpful, for they do not provide any instructions for recovery.	3,4
10	**Help and documentation**	
	10.1 The Help System is not appropriate for the user, since it refers to issues that are more relevant to the course designer (such as educator) than to the learner.	3
	10.2 It is not easy to search for information on the site.	2
	10.3 There is no obvious help given to show how to reduce the three-window design to a two- or one-window design.	1
	Category 2: Website-specific design (educational websites) heuristics	
11	**Simplicity of site navigation, organisation and structure**	
	11.1 The Course Material page should only have the content modules – Databases and Project Management. The Syllabus (Learner Guide) should not be on this page.	3
	11.2 There should be links to the different sections of the learner Guide to minimise scrolling and the Table of Contents should not only have links to its main sections, but also to its subsections.	3,4

	11.3 In the Table of Contents, for example, that of the Databases module, the Previous Page button should refer to the page that the user was on before the current one, but not to the previous section of the Table of Contents.	3
	11.4 In the Help window, the Back button should refer to the page that the user was on before the current one, but not to the previous section the Help System.	4
	11.5 Site content is not arranged hierarchically, from general to specific.	2
	11.6 In order to improve on the readability of the Course Menu, there should be bigger spaces between its different sections than between items of the same sections.	2
	11.7 On the Course Menu, the Communicate option should be positioned last, so that there is space for it to grow its submenu as more information is subsequently added, for example, new notices.	2
	11.8 The Breadcrumbs of the site come out clearly when the links within the page are used for navigation, but do not come out when the Course Menu links are used.	2
	11.9 On the Course Menu, Term Test 2 Scope link should not be aligned with the links on the Home Page since it is not on the Home Page.	2
	11.10 There should be lines between the different windows in the two- or three-window design.	2
	11.11 The Course Menu should be wider than it is to enhance its readability.	2
	Category 3: Learner-centred instructional design heuristics	
13	**Clarity of goals, objectives and outcomes**	
	13.1 Course goals are not clear.	3
	13.2 The main course goals/objectives should be visible or immediately accessible on the Home Page.	4
	13.3 Each link on the Home Page needs a brief description/indication, underneath it, of the information to be found by selecting it.	4
	13.4 Calendar information is not sufficient to assist the learner in determining what is to be done when.	3
14	**Collaborative learning**	
	14.1 Although facilities exist for learner-learner and learner-teacher interactions, there are no procedures in place to encourage their use.	3,4

18	**Feedback, guidance and assessment**	
	18.1 The feedback and the guidance provided via the system about the learners' activities (such as tests and assignments) are limited.	3,4
	18.2 Feedback should be more obvious to the user.	2
	18.3 There is limited guidance to the learners as they perform tasks, for example, apart from the explanation "The logical structure is visualized as a matrix composed of intersecting rows, one for each entity, and columns, one for each attribute" , a graphical illustration of this relationship should be provided.	1,3,4
	18.4 Diagrams and pictures should be used to illustrate learning concepts.	1
	18.5 The way content is provided to learners is sometimes misleading, for example, when the question "what are keys?" is asked; the question is not answered but instead, examples of the different keys are given.	1
	18.6 In order to guide learners, database specific jargon should be hyper-linked to the Glossary or to a section where they are explained later in the text. For example, in the sentence "The relational database makes use of *controlled redundancy* to maintain *integrity* while linking related tables", the italicised words should be hyper-linked to their meaning.	1
	18.7 In Question 1 of the quiz/test done during the evaluation, the word 'metadata' is shown as the correct answer but 'Metadata' is marked wrong. However, learners were not informed that the system is case sensitive.	1
	18.8 Glossary is inadequate. More terms/phrases need to be defined.	2
20	**Motivation, creativity and active learning**	
	20.1 There is no site content that encourages learners to compare, analyse or classify information so as to promote active learning or intuition.	2,4
	20.2 There are inadequate activities on the site to attract or engage learners.	3

Appendix C: Severity Rating Form and Results

Appendix C-1: Severity Rating Form

Evaluation of the e-learning website for Information Systems 3 at Walter Sisulu University

Heuristic evaluation: Severity rating of problems

Scale to use

Description	Score
Cosmetic problem: will not affect the use of the system. Fix it if possible.	1
Minor problem: users can easily work around the problem. Fixing this should be given a low priority.	2
Medium problem: users are likely to encounter this problem but will quickly adapt to it. Fixing this should be given medium priority.	3
Major problem: users will find this problem difficult but may be able to find workarounds. It is important to fix this problem. Fixing it should be given a high priority.	4
Catastrophic problem: users will be unable to do their work because of this problem. Fixing it is mandatory.	5
Not Applicable: I don't consider this to be a problem	N

Use the given scale to indicate the severity of each of the problems in the table that follows. Insert the numbers (1-5) or N alongside the problem in the **Sc** (Score) column to show your rating. In some cases, the statement in the 'Problem' column is not actually a problem. Rather, it is a proposal to rectify a problem or it is a suggested change (e.g. as in 2.1). In such cases please rate the underlying problem. For example, if you strongly agree with the proposal, then enter a score of 5. The **Ex** and **St** columns give weightings according to how many experts and students, respectively, identified the problem. The problems for each criteria are grouped in descending order, according to the number of experts who identified the problem.

	Problem			
	Category 1: General interface design heuristics			
1	**Visibility of system status**	**Ex**	**St**	**Sc**
	1.1 When doing a quiz/test, if an answer has already been saved and then if one changes his/her mind and selects another answer and clicks the Save Answer button, there should be feedback by the system to confirm that the later answer is the one accepted.	1	1	
	1.2 When submitting a quiz/test, the following message is given in a dialog box “All questions have been answered and all answers have been saved. Do you want to proceed?”. It is accompanied by an OK and a Cancel button. In this case the cancel option is confusing, since it is not clear whether it refers to the cancellation of this step or of the whole quiz/test.	1	0	
	1.3 When starting a quiz/test, the only button on this page is Begin Quiz. It is surprising that, when the Enter key is used, the system displays the same page, still with the Begin Quiz button, with the exception of the textbox and the instructions for entering the password.	1	0	
	1.4 In rare circumstances, when some of the links on the Course Menu (site index) are clicked, the message “WebCT™ has not been configured to run with framesets” appears and the Course Menu disappears. This is a surprise action.	1	0	
	1.5 The time allocated to do a quiz/test should be known before, instead of after the user clicks on the button to start the test.	0	1	
2	**Match between the system and the real world i.e. match between designer model and user model**	**Ex**	**St**	**Sc**
	2.1 Some labels/names should be changed if they are to be meaningful. For example, when notes are taken for the first time, the button for saving them should not be labelled ‘Update’, and the Calendar object should be called a Diary.	2	1	
	2.2 Symbols such as the icons used on the Home Page are not meaningful.	1	8	
	2.3 Some terminologies are unfamiliar; for example, under Discussions, the status of a topic could be ‘Public, Unlocked’. Learners (users) do not understand this. Similarly, the phrases ‘Content module’ and ‘Content	1	5	

	page', used by the Help System are unfamiliar to users.			
	2.4 The options, such as 'Content module table of contents', given in the dropdown list on the Search page should match those on the Course Menu options.	1	0	
	2.5 On the Communicate page, the options should be arranged in alphabetic order i.e. Discussion, Mail and Notice Board, instead of Discussion, Notice Board and Mail, as is the case now.	1	0	
	2.6 The visual layout of the Course Menu should be more natural in that items at the same site level should have the same alignment. For example, those on the Home Page (level 1) should have the same alignment.	1	0	
3	**User control and freedom**	**Ex**	**St**	**Sc**
	3.1 It is not easy to print site content, such as the Learner Guide and Content Modules. For example, there is no 'Print version' of the notes found in the hyperlinks in the Table of Contents.	3	2	
	3.2 There are no facilities for Undo and Redo.	2	16	
	3.3 Sometimes the system is slow to respond.	1	13	
	3.4 There is no system exit button.	1	12	
	3.5 There is no way to exit the Help System to the main system, apart from closing the Help window.	1	0	
	3.6 When doing a quiz/test, if the test is submitted before the time expires, one should have a chance to change answers within the time limit.	0	7	
4	**Consistency and adherence to standards**	**Ex**	**St**	**Sc**
	4.1 In order to be consistent, the format for the self test should be the same as that of the quiz/test. For example, a mark/grade should be allocated as is done with a quiz/test.	3	2	
	4.2 Same symbols/icons represent different things. For example, on the Home Page the icon for Student Resources is the same as that for Assessment.	1	7	
	4.3 There should be consistency in the spacing and size of items. For example, in the Learner Guide the spaces between some sections are single while other are double.	1	1	
	4.4 Background colour is white on some pages and blue on others.	0	6	
	4.5 All pages should have a title, but the Introduction does not.	0	1	

5	**Error prevention, specifically prevention of peripheral usability-related errors**	**Ex**	**St**	**Sc**
	5.1 The system does not give error messages to prevent errors from occurring.	1	3	
	5.2 In some cases, there are no ways to avoid erroneous/meaningless entries. For example, in Discussions, whatever is entered as a title or message is accepted.	1	2	
	5.3 When doing a quiz/test, the system should inform the user immediately he/she tries to move away from a question, that the answer selected is not saved. Instead, the user is informed at the end of the quiz/test.	0	3	
6	**Recognition rather than recall**	**Ex**	**St**	**Sc**
	6.1 It is sometimes difficult to recognise the relationship between different sections, between actions and their results or between controls and their actions. For example, in the Take Notes section, when the View All option is selected, it is difficult to know which notes relate to which section, and it is not easy to recognise that by clicking on the arrow next to the 'Course Menu' label the Course Menu window disappears or reappears.	4	1	
	6.2 Instructions on how to perform tasks should be visible; for example, they should be bold and/or in large font sizes.	2	3	
	6.3 When starting a quiz/test, after entering the password, there should be an Enter button next to the textbox for the password, instead of the Begin Quiz button which is several line spaces down from the textbox.	1	0	
	6.4 When there is a space in a fill-in-the-answer question in a quiz/test, it is not clear whether to insert the answer in that space or in the text box after the question.	1	0	
	6.5 On the View Results page for quizzes/tests, 'Attempt: 1/1' is confusing since the '1/1' could be mistaken for a score.	1	0	
7	**Flexibility and efficiency of use**	**Ex**	**St**	**Sc**
	7.1 The system cannot be customised.	3	5	
	7.2 There are no shortcuts provided.	2	4	
	7.3 It is not easy to perform tasks using some of the facilities such as the Calendar, Discussions and Help System.	2	1	
	7.4 The system is not flexible in its use.	1	3	
	7.5 The system does not cater for different levels of users.	1	2	

	7.6 When entering date/time values, in order to speed up data entry, the default values should be '00' instead of '--'. For example, if the user needs to enter the time as 13h00 in the Calendar, he/she should not be forced to select the '00' to replace the '--'.	1	0	
	7.7 It is not easy to navigate the system using the keyboard only.	0	7	
8	**Authenticity and minimalism in design**	**Ex**	**St**	**Sc**
	8.1 Notices on the Notice Board should show the dates when they were posted.	1	10	
	8.2 When starting a quiz /test, there should be one window with instructions on how to do the test followed by another window for entering the password. This would be preferable to clustering all the information on one window.	1	2	
	8.3 The use of a three-window design for the Table of Contents makes it difficult to read the content.	1	1	
	8.4 Instead of saving answers one-by-one, there should be one Save Answers button for the entire quiz/test, to minimise time loss.	0	1	
9	**Recognition, diagnosis, and recovery from errors**	**Ex**	**St**	**Sc**
	9.1 The error messages given are not helpful, for they do not provide any instructions to fix errors.	2	7	
	9.2 If a typed command (data) results in an error message, one has got to retype the entire command instead of repairing the faulty part.	0	3	
	9.3 When the wrong password is entered for a quiz/test, the error message should be in a text box instead of appearing on the screen where it is entered.	0	1	
10	**Help and documentation**	**Ex**	**St**	**Sc**
	10.1 It is not easy to search for information on the site.	1	3	
	10.2 The Help System is not appropriate for the user, since it refers to issues more relevant to the course designer (or educator) than to the learner.	1	2	
	10.3 There is no obvious help given to show how to reduce the three-window design to a two- or one-window design.	1	0	
	10.4 There is no FAQ section.	0	1	
	10.5 There is no section on how to use the site.	0	1	

	Category 2: Website-specific design (educational websites) heuristics	Ex	St	Sc
11	**Simplicity of site navigation, organisation and structure**			
	11.1 Site content is not arranged hierarchically, from general to specific.	2	2	
	11.2 There should be links to sections inside the same page/document to minimise scrolling.	2	1	
	11.3 The Back button should refer to the page that the user was on before the current one; for example, in the Help System the Back button should not refer to the previous section of the of the Help System but rather to the one visited before the current one.	2	0	
	11.4 In order to improve readability, the Course Menu should be wider, and the spaces between its different sections should be larger than the spaces between items of the same sections.	1	0	
	11.5 There should be lines between the different windows in the two- or three-window design.	1	0	
	11.6 On the Course Menu, the Communicate option should be positioned last, so that there is space for it to grow its submenu as more information is subsequently added, for example, new notices.	1	0	
	11.7 The Breadcrumbs of the site come out clearly when the links within the page are used for navigation, but do not come out when the Course Menu links are used.	1	0	
	11.8 Apart from the buttons provided by the browser, there should be a Back/Previous and Forward/Next button within the application.	0	19	
	11.9 There should be colour differences between the visited, non-visited and current site links.	0	3	
	11.10 The link to the library under Useful Links should link to the relevant study materials in the library, but not to the library's search section.	0	1	
	Category 3: Learner-centred instructional design heuristics	**Ex**	**St**	**Sc**
13	**Clarity of goals, objectives and outcomes**			
	13.1 Calendar information is not sufficient to assist the learner in determining what is to be done when.	1	6	
	13.2 Course goals are not clear.	1	3	
	13.3 Each link on the Home Page needs a brief description/indication, underneath it, of the information to be found by selecting it.	1	2	

	13.4 The main course goals/objectives should be visible or immediately accessible from the Home Page.	1	0	
14	**Collaborative learning**	**Ex**	**St**	**Sc**
	14.1 Though facilities for learner-learner and learner-teacher interactions exist, there are no procedures in place to encourage their use.	2	3	
	14.2 There are no facilities for synchronous communication such as video conferencing.	0	1	
18	**Feedback, guidance and assessment**	**Ex**	**St**	**Sc**
	18.1 There is limited guidance to the learners as they perform tasks. For example, the explanation "The logical structure is visualized as a matrix composed of intersecting rows, one for each entity, and columns, one for each attribute", should be supplemented with a graphical illustration (diagrams/pictures) of this relationship.	3	4	
	18.2 The feedback provided via the system about the learners' activities is limited and not obvious to the learners.	3	2	
	18.3 Glossary is inadequate. More terms/phrases need to be defined.	1	3	
	18.4 In Question 1 of the quiz/test the word 'metadata' is shown as the correct answer, but 'mettadata' and 'Metadata' are both marked wrong. However, learners were not informed that exact spelling is necessary or that the system is case sensitive.	1	2	
	18.5 The way content is provided to learners is sometimes misleading, for example, when the question "what are keys?" is asked; the question is not answered but instead, examples are given of the different keys.	1	0	
	18.6 In order to guide learners, database-specific jargon should be hyper-linked to the Glossary or to a section where terms are explained later in the text. For example, in the sentence "The relational database makes use of *controlled redundancy* to maintain *integrity* while linking related tables", the italicised words should be hyper-linked to their meanings or definitions.	1	0	
	18.7 Class lecture slides/notes, and quiz/test and assignment solutions should be available on the site.	0	3	
	18.8 There should be links to previous year's learning material.	0	1	
20	**Motivation, creativity and active learning**	**Ex**	**St**	**Sc**
	20.1 There is no site content that encourages learners to compare, analyse or classify information so as to promote active learning or intuition.	2	2	
	20.2 There are inadequate activities on the site to attract or engage learners.	1	3	

Appendix C-2: Severity Rating Results

Criterion	Problem	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Average
1	**1.1**	4	4	3	3	**3.5**
	1.2	3	2	3	4	**3.0**
	1.3	2	5	3	3	**3.3**
	1.4	2	2	4	4	**3.0**
	1.5	3	2	3	3	**2.8**
2	**2.1**	4	2	2	4	**3.0**
	2.2	4	4	4	4	**4.0**
	2.3	4	2	4	4	**3.5**
	2.4	3	3	1	3	**2.5**
	2.5	2	1	2	2	**1.8**
	2.6	2	2	3	2	**2.3**
3	**3.1**	5	1	4	4	**3.5**
	3.2	5	5	5	4	**4.8**
	3.3	4	1	2	4	**2.8**
	3.4	5	5	3	4	**4.3**
	3.5	2	5	2	3	**3.0**
	3.6	4	3	3		**3.3**
4	**4.1**	3	5	4	3	**3.8**
	4.2	4	5	4	4	**4.3**
	4.3	2	3	2	1	**2.0**
	4.4	3	4	2	1	**2.5**
	4.5	3	3	1	2	**2.3**
5	**5.1**	3	5	5		**4.3**
	5.2	3	4	4	2	**3.3**
	5.3	3	5	4	3	**3.8**
6	**6.1**	4	3	4	4	**3.8**
	6.2	3	2	3	3	**2.8**
	6.3	2	1	3	1	**1.8**
	6.4	2	2	2	2	**2.0**
	6.5	2	4	2	3	**2.8**
7	**7.1**	3	1	4	3	**2.8**
	7.2	3	1	4	3	**2.8**
	7.3	2	2	4	3	**2.8**
	7.4	3	3	3	3	**3.0**

	7.5	3	3	3	3	**3.0**
	7.6	2	3	3	2	**2.5**
	7.7	4	4	4	2	**3.5**
8	**8.1**	5	5	1	4	**3.8**
	8.2	4	2	1	2	**2.3**
	8.3	2	4	2	2	**2.5**
	8.4	2	2	2	1	**1.8**
9	**9.1**	4	5	5	4	**4.5**
	9.2	4	3	4	3	**3.5**
	9.3	3	3	1	1	**2.0**
10	**10.1**	4	4	3	3	**3.5**
	10.2	4	4	4	4	**4.0**
	10.3	2	3	2	1	**2.0**
	10.4	2	2	2		**2.0**
	10.5	2	5	2		**3.0**
11	**11.1**	2	5	3	3	**3.3**
	11.2	3	3	3	3	**3.0**
	11.3	3	3	2	3	**2.8**
	11.4	2	2	1		**1.7**
	11.5	2	2	1	1	**1.5**
	11.6	2	2	2	1	**1.8**
	11.7	2	4		2	**2.7**
	11.8	5	5	4	4	**4.5**
	11.9	3	4	2	1	**2.5**
	11.10	2	4	1	2	**2.3**
13	**13.1**	4	5	3	4	**4.0**
	13.2	3	5	4	4	**4.0**
	13.3	3	4	2	2	**2.8**
	13.4	2	2	1	2	**1.8**
14	**14.1**	4	3	3	4	**3.5**
	14.2	1	1	1	2	**1.3**
18	**18.1**	3	2	4	4	**3.3**
	18.2	3	4	4	4	**3.8**
	18.3	3	2	2	3	**2.5**
	18.4	4	5	5	4	**4.5**
	18.5	4	5	5	4	**4.5**
	18.6	3	5	4	2	**3.5**
	18.7	4	2	3	3	**3.0**

	18.8	2	2		2	**2.0**
20	**20.1**	4	4	3	3	**3.5**
	20.2	4	3	3	4	**3.5**
Mean		**3.1**	**3.2**	**2.9**	**2.8**	**3.0**
Standard deviation		**1.0**	**1.3**	**1.2**	**1.0**	**0.8**

Appendix C-3: Severity Rating of First Two Problems of each Criterion

Criterion	Problem	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Average
1	**1.1**	4	4	3	3	**3.5**
	1.2	3	2	3	4	**3.0**
2	**2.1**	4	2	2	4	**3.0**
	2.2	4	4	4	4	**4.0**
3	**3.1**	5	1	4	4	**3.5**
	3.2	5	5	5	4	**4.8**
4	**4.1**	3	5	4	3	**3.8**
	4.2	4	5	4	4	**4.3**
5	**5.1**	3	5	5		**4.3**
	5.2	3	4	4	2	**3.3**
6	**6.1**	4	3	4	4	**3.8**
	6.2	3	2	3	3	**2.8**
7	**7.1**	3	1	4	3	**2.8**
	7.2	3	1	4	3	**2.8**
8	**8.1**	5	5	1	4	**3.8**
	8.2	4	2	1	2	**2.3**
9	**9.1**	4	5	5	4	**4.5**
	9.2	4	3	4	3	**3.5**
10	**10.1**	4	4	3	3	**3.5**
	10.2	4	4	4	4	**4.0**
11	**11.1**	2	5	3	3	**3.3**
	11.2	3	3	3	3	**3.0**
13	**13.1**	4	5	3	4	**4.0**
	13.2	3	5	4	4	**4.0**
14	**14.1**	4	3	3	4	**3.5**
	14.2	1	1	1	2	**1.3**
18	**18.1**	3	2	4	4	**3.3**
	18.2	3	4	4	4	**3.8**
20	**20.1**	4	4	3	3	**3.5**
	20.2	4	3	3	4	**3.5**
Mean		**3.6**	**3.4**	**3.4**	**3.4**	**3.5**
Standard deviation		**0.9**	**1.4**	**1.1**	**0.7**	**0.7**