EVALUATION OF A NEW ONLINE LEARNING RESOURCE-

The Human Computer Interface Design

BY

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Declaration

Apart from the assistance, which is acknowledged, and quotations specifically referenced in the text, this thesis is entirely my own work, and has not been submitted for a degree at any other university. The statements made and the views expressed are solely the responsibility of the author.

Signed by.....................................

E. W. Gachie

Date..

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PREFACE AND ACKNOWLEDGEMENTS

In everything I do, I give Glory and honour to the Lord, my God and personal saviour.

I would like to extend my heartfelt appreciation to my supervisor, Professor Alan Amory. Thank you for your guidance and support, and for taking time off your busy schedule to look at my work during the entire period of this study. Thank you once more for the constructivism-learning environment under which I undertook my studies.

I thank my husband, Gachie Njagi, and my son, Munene Gachie for their support and patience during the period of my studies in the Digital Media program and while working on this dissertation. Thank you for helping me understand that a seemingly insurmountable task can be worked at with patience and ultimately transformed without undue fuss.

I would also like to pass my gratitude to Mr Paul Rhoda and Dr Nicola Rhoda, Ms Patsy Clarke and Mr Steven Yates for everything they have done towards the success of this study. To Professor Ari Sitas, I am most grateful for giving me an opportunity to gain relevant work experience while working on this project and for financial assistance during this period.

Last but not least, to all my friends, near and afar, I thank you from the bottom of my heart for your support throughout my studies.

Articulation

Who said doing research is boring? It is not. For the last one year that I have been undertaking this research, this has been one of the most exciting periods of my life.

This study has made me to appreciate the importance of planning and evaluation in design, not only of educational software but also in web designing. I have realised that the field of Human Computer Interface (HCI) is enormous and a lot has to be done in that field to ensure user satisfaction and overall success of the design of educational software.

Developing an own educational evaluation style was one of the reasons for undertaking this research. This is based on my developed interest in the field of HCI. During the period, *'Designing-by-Constructivism'* model was developed. The major theme of this research project is based on this model.

Creativity was another part of this research project. This is because creativity was needed to think of how to relate and integrate the constructivism epistemology, Rich Environment for Active Learning (REAL), the User Centred Design (UCD) approach and Human Computer Interface (HCI) design principles in the evaluation of the Open Learning System (OLS). Doing action research means that you are being exposed to the realities of education and to the unexpected situations that may arise form it. Though not always fun at the time, these unexpected situations are the most fun to think of afterwards. Often these situations had something to do with the participants responding differently than expected. Creativity and often-prompt actions and questions were needed to solve these situations.

Not only have I developed good research skills but I have also developed Internet search skills, communication skills, improved my typing and writing skills, reflection and journalising and a better understanding of several issues that underpin the use of technology in learning. One thing that I have appreciated the most is that learning is not a change in behaviour but a change in the whole human being: perception, attitude, viewpoint and a wide range of social skills. A person who is self reliant in learning has emerged. This has been through scaffolding by my supervisor Professor Alan Amory, thereby eventually resulting in a more self-regulated researcher. This research project appeared like a giant ready to swallow me but through scaffolding that I have received from my supervisor among other individuals, I have been able to successfully complete what I had viewed as impossible.

Thank You!

ABSTRACT

With the increasing demand for online learning, well-designed computer online learning resources are indispensable. User interfaces evaluation has become a critical quality attribute of interactive software intended to meet the requirements of the user groups. It is this aspect of adaptations that make them critical for the study of evaluation of user interfaces. This study describes a preliminary evaluation of the user interface design of a new online learning resource (Open Learning System). The main objectives of the study are to investigate the effect of the interaction on the user (usability, efficiency, effectiveness and satisfaction), to assess the extent of the system (resource) functionality and to identify specific problems in the design (aspects of design that cause unexpected results or confusion). This will form part of iterative design and testing process of the new interface, which seeks to evaluate the success of the interface within the framework of the fundamental HCI principles under guidelines of the constructivists learning approach. The Open Learning System (OLS) is grounded on the constructivist-based learning approach. The underlying philosophy of the system assumes when learners are engaged in a social learning context, they actively construct knowledge, therefore the resource is considered as a tool to support learning and not an end in itself. By so doing it is geared to provide greater access to information, support Computer-Mediated Communication (CMC) using tools such as e-mail, chat and discussion forum and creating context for learners' work and peer review. A theoretical framework for evaluating the OLS was developed and proposed which comprised of the constructivist epistemology, Rich Environment for Active Learning (REAL), the User Centred Design (UCD) approach and the Human Computer Interface (HCI) design principles. This integrated theoretical framework has been referred to as *'Designing-by-Constructivism'* model. The study investigates the use of the OLS by two sets of users: staff members (module creators) and learners (module consumers). In view of the fact that the data collected is qualitative, the approach assumes the use of semi-structured questionnaires, evaluation matrix and interviews. The information/feedback gathered will assist the developers to do preliminary reviews. The study will also be useful to academics pursuing more HCI issues or those with an interest in developing learning resources. The main elements of the *'Designing-by-Constructivism'* model were present in the resource. The results analysis indicates that the

resource supports collaborative learning and the use of authentic activities in learning. This serves as an intrinsic motivation to most of the users. The results also show a high degree of user satisfaction and appreciation of OLS resource. Largely, the participants are satisfied that the overall OLS design met their needs. The major contribution being, *"OLS is interactive and user friendly"*. However, some users have expressed the desire to have more tools incorporated into the resource, while others have expressed concern about difficulties in logging into the system.

CHAPTER ONE

INTRODUCTION

"The richness of technology permits us to provide a richer and more exciting learning environment... our concern is the new understandings and new capabilities that are possible through the use of technology" (Duffy & Cunningham, 1996:187).

1.1 Structure of this study

This research can be described as a process involving the following five chapters:

Chapter 1 (Introduction) – Provides with an overview and the reasons why this research was necessary.

Chapter 2 (Literature review) – Provides the theoretical motivation of this research. Here, a discussion is made on the emerging pedagogies, approaches and concepts that are important in educational software design, whereby insights and ideas are generated which will either be accepted or refuted in the results and discussion. A theoretical framework is developed and proposed which comprises of the constructivist epistemology, Rich Environment for Active Learning (REAL), the User Centred Design (UCD) approach and the Human Computer Interface (HCI) design principles. This integrated theoretical framework has been referred to as *'Designing-by-Constructivism'* model

Chapter 3 (Research methodology and methods) – Aims to make the results more valid and reliable. Qualitative and quantitative instruments have been employed in this study; these are questionnaires, evaluation matrix and interviews.

Chapter 4 (Results and discussion) – Seeks to analyse and interpret the data. This is done with the aid of SPSS and NVivo, computer software packages for quantitative and qualitative analysis respectively. Attempts to relate the theoretical insights gained in Chapter 2 to a broader variety of the results are also made.

Chapter 5 (Conclusion and recommendation) – Further describes the theoretical and practical motivations, relationships, reflections, recommendations, and further research in depth on design of educational software with special reference to the Open Learning System (OLS) (see figure 2 for a snapshot of OLS).

The structure of this thesis can be illustrated as in Figure 1 below
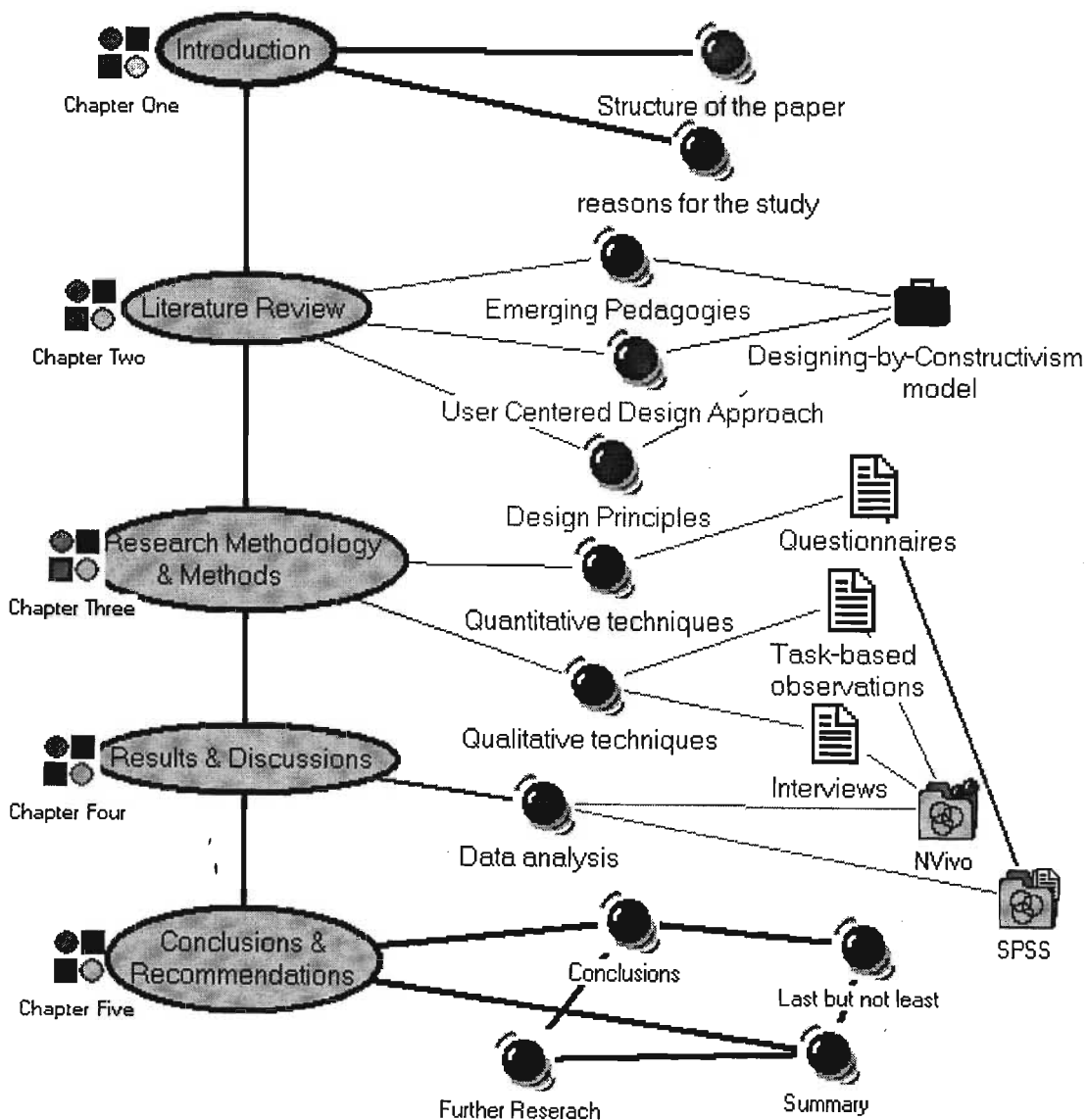
Figure 1: Pictorial representation of the study

1.2 Introduction

Human-Computer Interaction (HCI) is the study of how people design, implement, and use interactive computer control and display systems, and how these systems affect

individuals, organizations, and society. This includes not only ease of use but also the interactive techniques needed for supporting user tasks, providing better access to and interpretation of information, and creating more effective forms of communication. HCI also involves input and output devices and the interaction techniques that use them; how information is presented and requested; how computer actions are controlled and monitored; all forms of help, documentation, and training; the tools used to design, build, test, and evaluate user interfaces; and the processes that developers follow when creating suitable interfaces (Dix *et al.*, 1993).

Human-centred design is characterised by: the active involvement of users and a clear understanding of user and task requirements; an appropriate allocation of function between users and technology; the iteration of design solutions and multi-disciplinary design (ISO 13407, 2003). HCI also includes all aspects of the human experience from the obvious ones of screen layout and selection options as well as input and output devices, reliability and accessibility (Shneiderman, 1987). Examples of these experiences have to do with the font size, colour, and layout among others.

Interface design is important because pleasant, attractive, easy to use software is well accepted and successful. Interface is the part of the system, which the user sees, hears and communicates with (Thimbleby, 1990). Depending on their experience with the interface, a computer system may succeed or fail. Poor interface design can have the following consequences: increased mistakes in data entry and system operation, user frustration, poor system performance, and system failure. HCI bridges, to an extent, the gap between systems analysis and design, and knowledge-based systems, having a methodological similarity with the former and a theoretical basis largely shared with the latter (Sutcliffe, 1988). User-interface structure is self-evident, easy to navigate, and visually compelling. It illustrates the graphic style, theme, and/or metaphor that ensure coherence of software or a web site and support branding initiatives. This call for the importance to understand the users needs in the evaluation process, hence the User Centred Design (UCD) approach.

The User Centred Design (UCD) approach comprises a set of several steps, methods and tools designed to assist evaluator(s) in addressing the issue of usability in design of interactive systems. The UCD approach assists in the process of collating design information obtained using a variety of user oriented data gathering techniques. The essence of the UCD approach is that it provides a structure to assist the developer in assuring that relevant design issues have been considered in a user oriented manner. Individual methods and tools may be visited and revisited a number of times in an iterative design process. The UCD approach should be seen as a methodology for collating design material rather than a design model per se. From this perspective, UCD acts as a framework rather than a detailed design method in its own right. Design usually involves a number of common activities. Typically these include: problem definition phase; development of a functional specification; building phase, and testing or evaluation phase (Rauterberg, 2003).

This study is specifically concerned with the evaluation phase. Evaluation is the process by which people make value judgments about things. In the context of learning technology, these judgments usually concern the educational value of innovations. Less frequent, but still important, are judgments about the costs of such innovations (Oliver, 2000). This is the judgment about 'worth', as opposed to 'value', in the terminology (Guba & Lincoln, 1981). Therefore user interface evaluation implies a set of activities, methods and tools that are dedicated to assessing software design. Evaluation during the development process is essential as HCI issues when identified early, are easier to correct. This may help to avoid extra work in later phases of the project (Shneiderman, 1987), hence the need for a preliminary evaluation of the OLS.

In the process of evaluating the OLS, the study will also pay focus on the use of online learning technology in education. Traditional forms of education are being transformed concurrently with advancement in technology. The use of technology in delivery of education can offer a vibrant learning environment created through different strategies and activities. The term technology in education refers to a wide range of electronic materials

and methods of learning. Technology has extended beyond the walls of a single room thereby pulling content and experience from remote locations and has enabled students to participate in real-time from remote sites. These technologies include information and communication technologies.

This educational technology, especially online learning, can provide educators with an opportunity to develop new learning experiences for students that have not been possible before (Alexander, 1999). However it is important to do preliminary evaluations so as to understand how the users perceive and learn using a new learning medium.

Online learning refers to the context within which learning takes place, or the means of course delivery – for example, a web-based course via a computer network. Reeves, Herrington and Oliver (2002) define online learning as content, tasks, problems, collaboration and feedback mediated by a network computer. This is one of the methods to facilitate distance learning. Online learning should foster collaboration among students. This may in turn have a positive effect on students' achievements. Online groups and discussions can benefit the learners significantly from their involvement in small learning groups. These groups provide support and encouragement along with extra feedback on course assignments. Most importantly, the groups foster the feeling that if help is needed it is readily available. The learner is also motivated as frequent contact between the learner and the course facilitator is possible.

The source code for OLS will be open and available for those who wish to alter, improve, or customize it with adherence to the license agreement. The philosophy behind the system places values on the viewpoint of shared knowledge in the tradition of intellectual freedom.

With the increasing demand in online learning, appropriate resources are becoming imperative in this field. Frequently, however, these resources are introduced without consultation with users. It is therefore important to evaluate the interface of the resource with the target audience in this case the students and course facilitators.

Effective systems generate positive feelings of success, competence, and clarity in the user community. These users are not encumbered by the computer and can predict what happens with each of their actions. When an interactive system is well designed, it almost disappears, enabling the users to concentrate on their work (Shneiderman, 1987). Creating an environment, in which tasks are carried out almost effortlessly, requires a great deal of work hence, the need for preliminary evaluation.

Similarly, researchers have shown that evaluating and redesigning the human-computer interface can make a substantial difference in learning time, performance speed, error rates and user satisfaction. Hence success will come to people who take a disciplined, iterative, and empirical approach to the study of human performance in the use of interactive systems (Nielsen, 1993). The study involved using a combination of different theories, approaches, techniques, data analysis, research methodologies and instruments to form one study of a single phenomenon and to converge on a single construct – *'Designing-by Constructivism'* model.

First, the study intends to investigate the effect of interaction on users (usability-efficiency, effectiveness and satisfaction). Secondly, it assesses extent of the system (resource) functionality. Finally, the study tackles and identifies specific problems in design of OLS (aspects of design that cause unexpected results or confusion). The grounds of the preliminary evaluation of the OLS were to obtain feedback on the following: layout-colour, graphics; interactivity; navigation; language; information presentation; visual consistency and user autonomy (control).

Bearing in mind that designing is a non-hierarchical process (does not necessarily involve moving from one step to another), which is dynamic in nature apart from the HCI design principles; reference has also been made to User-Centred Design (UCD), constructivism epistemology and Rich Environment for Active Learning (REAL) approach. This approach has been integrated with some of the principles/guidelines, which are fundamental to design, and implementation of effective interfaces (The Apple computer 1987; Nielsen

1993; Tognazzini 1998). According to Shneiderman (1987) application developers who apply human factors, principles and processes are producing exciting interactive systems. These principles are: anticipation, autonomy, graphic design and colour, consistency, language, efficiency of the user, explorable navigation interfaces, adaptability, presentation learn-ability, metaphor use, flexibility, readability, errors, memory load, accessibility, and protection of users' work, track state and visible navigation.

Rich Environments for Active Learning or REALs are comprehensive educational systems based on constructivist principles, a concept developed by Grabinger and Dunlap (1995, 1997.) The theory of the REAL argues that truly successful learning comes from an integrated approach where students are encouraged to take responsibility for their learning through generative learning activities in authentic, realistic contexts and assessed on their learning in varied ways that encourage and demonstrate higher-order thinking and a collaborative approach (Grabinger and Dunlap, 1997).In constructivism philosophy, learning involves reorganization or restructuring of previous experiences, so that one comes to perceive things in a new way. This can be achieved through the supplying of appropriate amount of information for the learner and in the mode of presentation; that is the use of simple and easy connections, hence the importance of making reference to constructivism epistemology.

How can online learning systems be designed around the user needs? Which are the most important HCI principles in the design of learning systems? Which are the most important features and tools that should be integrated in learning software? How can the emerging pedagogies influence the design of learning systems? Which are the most important themes to be considered in the design of educational software? How do people perceive online learning? How does design of educational software influence learning - such as collaboration, situated learning and scaffolding? This research sought to answer these key questions through the literature review and research questions and analysis. Motivations and results of this study were practical as well as theoretical.

Below is a snapshot of one of the OLS pages with default customization theme and icons (Figure 2).
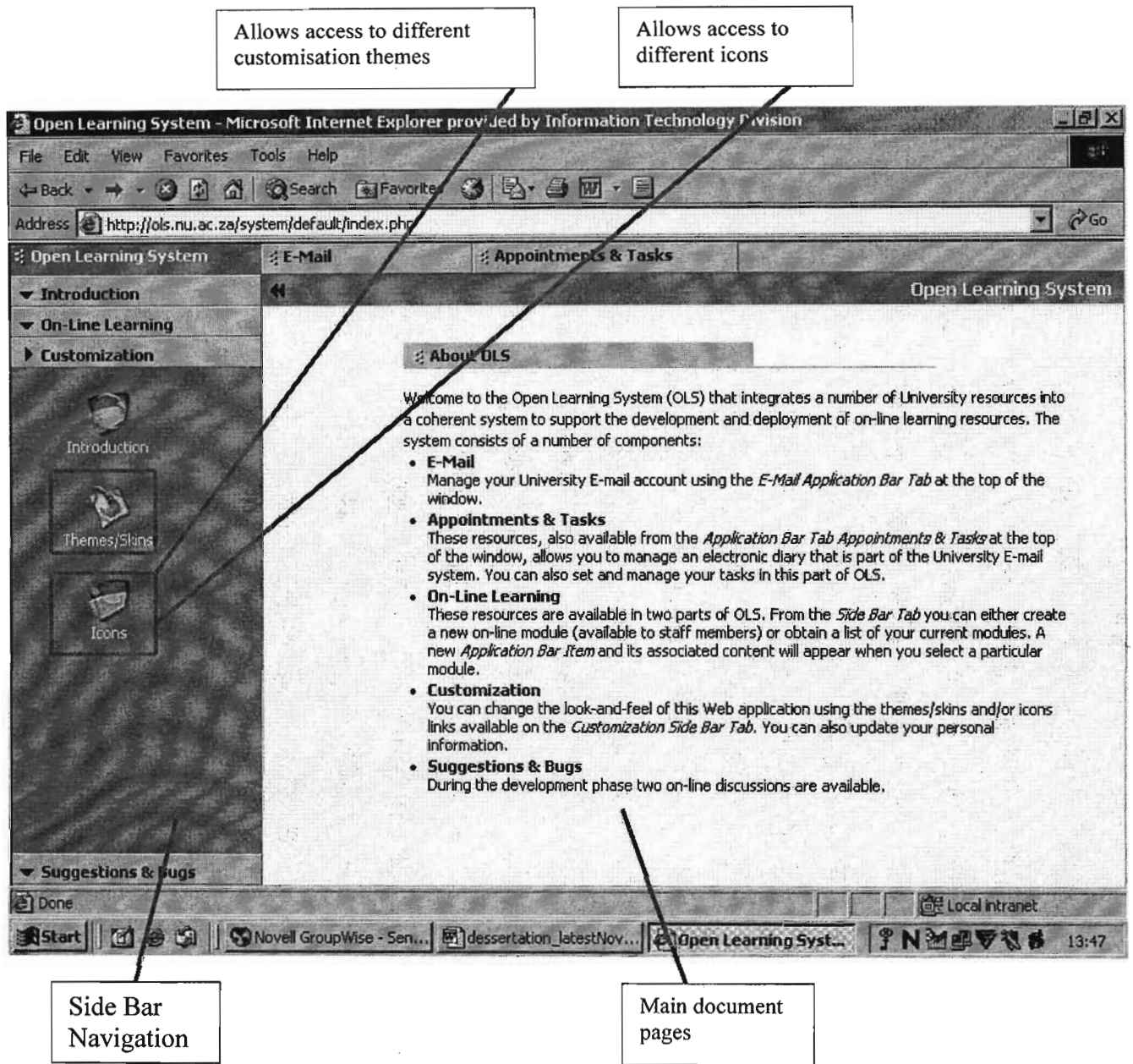
Figure 2: Screenshot of OLS home page

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

An examination of existing literature shows that on-line learning can be as effective as any other method of learning; this is so particularly when the method and technologies used are appropriate and there is student-to-student interaction, and when there is timely teacher-to-student feedback (Moore and Thompson, 1990).

Without exception, effective online learning programs begin with careful planning and a focused understanding of course requirements and student needs. Amsy (2003) posit that successful programs rely on consistent and integrated efforts of students, faculty, facilitators, support staff, and administrators.

This chapter seeks to describe, explain and understand studies that show how preliminary evaluation of a learning resource can assist in making design decisions and determining whether or not the developed product achieves the quality measurements defined. The chapter also seeks to establish a relationship between the practical and the theoretical motivation of this research. The theoretical insights and motivations include emerging pedagogies, concepts and issues related to creation of an effective learning resource. These theoretical developments and their relationship to practical motivations are described partly towards the end of the same chapter, in Chapter 4 (Results and discussion) and in Chapter 5 (Conclusion and summary). One of the studies explored shows how computer based learning tools enhances human cognition. Some of the issues and approaches discussed include: the user centred design approach, design principles, constructivism epistemology, computer-mediated communication, scaffolding and rich environments for active learning.

Four major theoretical aspects of evaluating OLS are explored and discussed in this chapter. These four aspects can be broadly categorized into two issues: (A) *conceptual issues relating to the support of learning* – constructivism epistemology (Section 2.2) and

Rich Environments for Active Learning – REAL (Section 2.23); and (B) *conceptual issues relating to software design* – UCD approach (Section 2.3) and HCI principles (Section 2.4). In Section 2.5, these four theoretical aspects have been integrated to form one emerging reference model- *'Designing-by-Constructivism'* (See Figure 11 and 20 which are graphical and pictorial illustrations of these four conceptual issues). This model gives directions for evaluating the design of the OLS. Apart from giving the directions for evaluation of design process, these four aspects are integrated into the model to guide decisions about the evaluations of technological learning environments. The reference model is introduced after the discussion of these four theoretical frameworks. For clarity and coherence of this study, the reasons for adopting a combination of approaches, principles and theories in evaluation of OLS are first discussed.

2.2 Reasons for integrating constructivism epistemology, REAL and UCD approach in evaluation of the Open Learning System HCI design

HCI involves the interactions and relationships between humans and computers. It is a multidisciplinary field covering many areas, having a different focus depending on a disciplinary point of view. In the first ten to fifteen years of its history, HCI has focused on interfaces (particularly on the possibilities and design criteria for Graphical User Interfaces (GUIs) using windows, icons, menus, and pointing devices (WIMPs)) to create more usable systems. As interface problems were better understood, the primary HCI concerns started to shift beyond the interface to respond to observations as articulated by Engelbart (1997): *"If ease of use was the only valid criterion, people would stick to tricycles and never try bicycles"*. More recent HCI research objectives are concerned with tasks, with shared understanding, and with explanations, justifications, and argumentation about actions and not just with interfaces. The new essential challenges are improving the way people use computers to work, think, communicate, learn, critique, explain, argue, debate, observe, decide, calculate, simulate, and design. A fundamental objective of HCI research is to make systems more usable, more useful, and to provide users with experiences fitting their specific background knowledge and objectives. The challenge in an information-rich

world is not only to make information available to people at any time, at any place, and in any form, but specifically to say the 'right' thing at the 'right' time in the 'right' way. That is to be designers of collaborative human-computer (Olson and Olson 1997).

With such ongoing discussions about taking HCI principles a step further beyond interface evaluation and with the view that HCI is a discipline that is concerned with the design, evaluation and implementation of interactive computing systems for human use and the study of major phenomena surrounding them (Hewett *et al.,* 1996), we realize that there exists a link between the constructivism epistemology, REAL, UCD approach and HCI design principles, hence the reason of using these approaches, principles and theories in evaluation of OLS. Moreover the social constructivism perspective is geared towards a shared knowledge, which can be facilitated by CMC tools. Apart from just evaluating these CMC tools from a HCI perspective, it is important first to understand these tools from a constructivist, REAL and UCD perspective.

Similarly, HCI is largely an interdisciplinary area. It is emerging as a specialty concern within several disciplines, each with different emphasis such as psychology (the application of theories of cognitive processes and the empirical analysis of user behaviour) and computer science (application design and engineering of human interfaces), to name but a few. Therefore, interaction of people and computers and the uses of computers are certainly parts of these phenomena. This is because HCI involves the communication between a human and a machine; it draws from supporting knowledge on both the machine and the human side. On the machine side, techniques in computer graphics, operating systems, programming languages and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, and human performance are relevant. Of course, engineering and design methods are relevant too (Hewett *et al.,* 1996). Therefore a relationship between HCI principles and constructivism epistemology will be drawn with the concern being the human information processing and performance. These relationships

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concentrate on: learning of systems, transfer of that learning, mental representation of systems by humans and human performance on such systems.

Similarly, it is presumed that OLS is grounded on constructivism epistemology and around user needs. Therefore it is important for the literature review to encompass these two conceptual issues, which contain large amounts of information that are related to human computer interaction that investigate the social and cultural aspects of technology use and design. A broad review of constructivism epistemology will be done (that is both cognitive and social perspective) since this will enable the researcher to determine the grounding and perspective of OLS during the results and discussions.

Therefore, the main aim of this literature review was to establish the existing approaches in design of learning resources to supporting students and course facilitators via web based learning environments and how these approaches reflect the paradigm shift about learning. The other aim was to find out the important design features, tools and elements of supporting the users in this learning environment.

2.3 Emerging Pedagogies

Understanding of theories is important as they facilitate comprehension, prediction, control, and interpretation of 'reality'. Indeed it is possible to go further and argue that without a theory of some sort it is impossible to understand 'reality' (Marsh and Storker, 1995). Educational theory assists in the design and implementation of a learning project, with eventual results being in quality of the final product.

Many dimensions have been used to evaluate educational theories. Reeves (1997) presented these dimensions in fourteen different pedagogical dimensions. These are epistemology (objectivism versus constructivism), pedagogical philosophy (instructivism versus constructivism), underlying psychology (behavioural versus cognitive), goal orientation (sharply-focused versus unfocused), experimental validity (abstract versus

concrete), teacher role (didactic versus facilitative), flexibility (teacher-proof versus easily modifiable), values of errors (errorless learning versus learning from experience), origin of motivation (extrinsic versus intrinsic), accommodation of individual differences (non-existent versus multi-faceted), learner control (non-existent versus unrestricted), user activity (mathemagenic versus generative), cooperative learning (unsupported versus integral), cultural sensitivity (non-existent versus integral). These structures show that a shift in educational paradigm from instructivism to constructivism is occurring in all educational levels.

The focus in learning is moving away from reproduction of content knowledge (instructivism) towards an emphasis on learning as a process of higher order thinking and an ability to produce new knowledge (constructivism). The role of the teacher is also changing from information provider to facilitator of learning (Fapojuwo, 2003). Several authors who have done studies on learning theories and approaches such as Rieber (1993); Duffy, Jonassen and Lowyck (1993); Papert (1993) have made clear distinctions between instructivist and constructivist approaches to teaching and learning. Another way of thinking about these orientations is in terms of pedagogical epistemology and philosophies (Epistemology is the concerned with the nature of knowledge, its presuppositions and foundations, and its extent and validity (Cambridge Advanced Learner's Dictionary, 2003).

Figure 3: Pedagogical structure of Educational theories

Education is in the midst of a paradigm shift from an information processing explanation to a constructivist approach to learning. Naturally online learning has been involved in this shift, which is learner centred. This is built on the current thinking in educational transition upon pedagogical terms such as situated learning, collaboration, scaffolding, authentic activities, and critical thinking (Reeves, 1993). Pedagogy refers to the art and science of teaching and learning (Cambridge Advanced Learner's Dictionary, 2003)

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The effectiveness of technology in any learning environment depends upon the degree that it supports appropriate pedagogical dimensions. In particular, this pedagogy builds on the "problem-based learning" Jones (1996), "constructivism" Reeves (1993) and "communities of practice" (Jonassen, Peck and Wilson, 1999) literature. This pedagogical strategy aims to create an environment, which allows the different benefits of each of these pedagogical approaches to be made explicit. Such learning styles and strategies can be encouraged by the use of technology such as online learning.

This shift came as a result of many academics viewing the instructivism approach as unsatisfying in areas of problem solving and learning strategies, they became more concerned with what was unobservable - what was going on inside the brain. Constructivism is not a theory about teaching; it is an epistemological position. Fosnot (1996) sees constructivism as fundamentally nonpositivist and as such it stands on completely new ground – often in direct opposition to both behaviourism and maturationism. Rather than behaviours or skills being the goal of instruction, concept development and deep understanding are the foci; rather than stages being the result of maturation, they are understood as constructions of active learner reorganization.

Constructivist learning is based on students' active participation in problem-solving and critical thinking regarding a learning activity that they find relevant and engaging. They are 'constructing' their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs. Central to constructivist pedagogy is the idea of learning as 'constructing meaning', and learning as the 'negotiation of meaning'. Constructivists do not subscribe, as many claim that they do, to the view that all meaning is equally valid because it is personally constructed. Within any knowledge-building community, shared ideas are accepted and agreed upon. That is, meaning is reflected in the social beliefs that exist at any point in time by a certain community (Jonassen, Peck and Wilson, 1999).

Kolb (1984) provides a useful model of processes involved in constructivist learning. He proposes that learning is a cyclic activity with four stages: concrete experience, reflection, abstract conceptualisation, and experimentation. This reflection allows the learners to make sensible decisions on where to go next in the learning process. Reflections could encourage students to respond to what they are reading or learning and to think deeply about their own personal knowledge throughout the whole process.
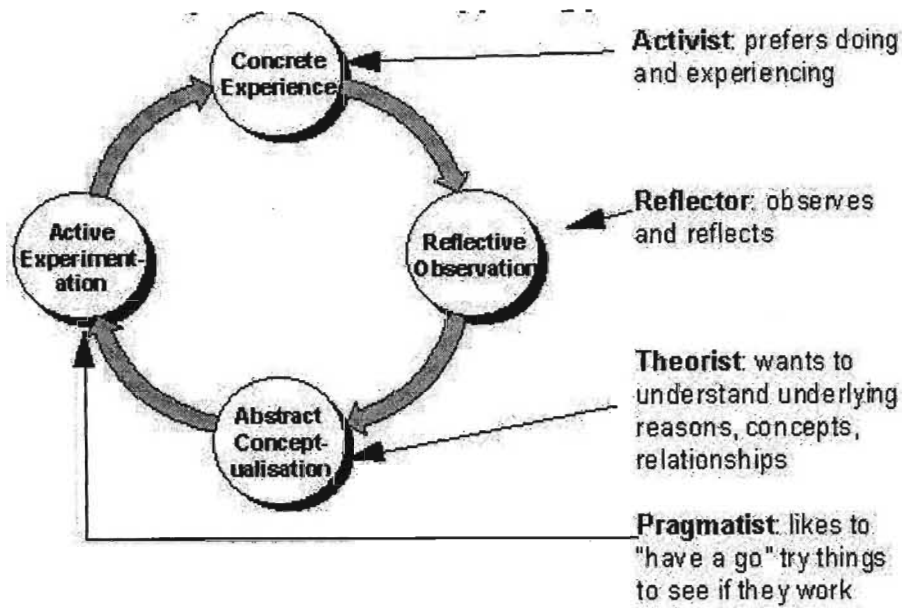
Figure 4: Kolb's model of experiential learning process
Reprint from Atherton (2002)

In this approach the underlying principle is the belief that knowledge is not separate from, but embedded within experiences and interpreted by the learner. Hence knowledge is about interpretation and making sense of the environment, and each person conceives it in different ways based on their prior experiences, belief structures and perspective. From the constructivism point of view, interpretation can include different types of knowledge construction and not memorization of factual knowledge or procedures (Eysenck and Keane 2000; Wild and Quinn, 1998 cited in Fapojuwo, 2003). The aim of the learner is to

build and re-invent knowledge, order and re-order knowledge, test it out and justify this interpretation.

The constructivist approach is based on the work of several educational philosophers John Dewey, and educational psychologists Lev Vygotsky, Jean Piaget, Howard, Nelson and Goodman among others who have studied the role of representation (for example symbols, illustration, demonstration etc) in learning (Fosnot, 1996), with Jerome Bruner being viewed by many as father of constructivism approach.

A major theme in the theoretical framework of Bruner (1960) is that learning is a building process by active learners in which they construct new ideas or concepts based upon their current or past knowledge. The learner selects and transforms information, constructs hypotheses, and makes interpretive and recursive decisions. The learner does so by relying on cognitive structures and by interacting with the physical and social world. Cognitive structure (schema, mental models) provides meaning and organization to experiences and allows the individual to go beyond the information given (Tuckman, 1979). Learners construct knowledge for themselves, each learner individually and socially constructs meaning, as they learn. They are encouraged to discover facts and relationships for themselves.

Bruner (1960) argues that course facilitators should try and encourage students to discover principles by themselves and engage students in an active dialogue that is socratic learning. Curriculum should be organized in a spiral manner so that the student continually builds upon what they have already learned. This author also states that a theory of learning should address four major aspects: predisposition towards learning; the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner; the most effective sequences in which to present material, and the nature and pacing of rewards and punishments. He theorized that learning is dependent on how information is structured, organized and conceptualised. He further proposed a cognitive learning model

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that emphasized the acquisition, organization (structure), understanding and transfer of knowledge, focusing on 'how' to learn, rather than 'what' to learn. This approach was characterised by three stages, which he calls enactive, iconic and symbolic and are solidly based on the developmental psychology of Jean Piaget.

When dealing with the enactive mode, one is using some known aspects of reality without using words or imagination. Therefore, it involves representing the past events through making motor responses; mainly knowing how to do something and a series of actions that are right for achieving some result (Bruner, 1960).

The author further sees the iconic mode as dealing with the internal imagery, were the knowledge is characterised by a set of images that stand for the concept. The iconic representation depends on visual or other sensory association and is principally defined by perceptual organisation and techniques for economically transforming perceptions into meaning for the individual.

In the symbolic mode the author observes that through life one is always adding resources to the symbolic mode of representation of thought. This representation is based upon an abstract, discretionary and flexible thought. It allows one to deal with what might be and what might not, and is a major tool in reflective thinking. This mode is illustrative of a person's competence to consider propositions rather than objects, to give ideas a hierarchical structure and to consider alternative possibilities in a combinatorial fashion.

In his more recent work, Bruner (1986, 1990, and 1996) has expanded his theoretical framework to encompass the social and cultural aspects of learning.

Reeves, Herrington and Oliver (2002) view a constructivist classroom as exhibiting the following elements: problem based activities, visual format and mental models, 'Rich' learning environments, symbol pads and construction kits. In line with the constructivism

perspective to learning, the following constructivist principles can be applied in all educational environments. Anchor all learning activities to a larger task or problem; support the learner in developing ownership for the overall problem or task design authentic tasks; design the task and the learning environment to reflect the complexity of the environment they should be able to function in at the end of learning; give the learner ownership of the process used to develop a solution; design the learning environment to support and challenge the learners' thinking; encourage testing ideas against alternative views and alternative contexts; provide experience on the knowledge construction process; present learning in a realistic and relevant context; encourage participation in the learning process; insert learning in a social experience; encourage multiple ways of knowledge representation and encourage self-awareness of the knowledge construction process.

The weakness seen in this approach is in a situation where conformity is essential divergent thinking and action may cause problems. Imagine a situation of citizens reporting their taxes in their own way. The strength depicted by this approach is that the learner is able to interpret multiple realities and is better able to deal with real life situations. If a learner can solve a problem, they may better apply their existing knowledge to a novel situation.

There exist two major strands of the constructivist perspective. These two strands are: cognitive constructivism and social constructivism. They are different in emphasis but share many common pedagogical perspectives. These two strands have come as a result of widespread interest between those who place more prominence on the individual cognitive structuring process and those whose prominence is on the social-cultural effects on learning. Currently there is a dispute between these two strands over whether the mind is located in the head or in the individual-in-social-action, and whether learning is primarily a process of active cognitive reorganization or a process of enculturation into a community of practice (Fosnot, 1996).

2.3.1 Cognitive Constructivism Strand

Cognitive constructivism, an individualistic perspective is based on the work of Swiss developmental psychologist Jean Piaget whose early work was in the field of biology, where he studied genesis of cognitive structures. Changes in behaviour are observed, and used as indicators as to what is happening inside the learner's mind, based on the thought process behind the behaviour.

The fundamental basis of learning, he believed, was discovery: to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition. In contrast to the behaviourists approach, the cognitive constructivism approach to learning emphasizes primarily on what goes on inside the learner's head. Cognitivists' view the learner's active part of the process not as just responding to circumstances but organizing and reorganizing incoming information in ways that have come to be called thinking and problem solving. The learner uses mental structures/models to process information, often with a unique or insightful result (Tuckman, 1979). Piaget believed that human beings are developing organisms, not only in a physical, biological sense, but also in a cognitive sense.

Piaget observed children from birth through adolescence. He often gave them tasks or experiments to solve, and meticulously described the results. From the observations, he formulated a theory of cognitive development with the schema as the basic unit, the schema being a repeatable action sequence governed by a core meaning. As development proceeds, schemata increase in number and complexity in order to direct the child's actions as he or she deals with objects and events (Tuckman, 1979). He came up with the notion that learning must be actively and internally constructed by the learner rather than explained.

The basic tenet of Piaget's theory is that the basis for intellectual growth and development is adaptation, of being able to deal with and function in a given environment. He took the notion of adaptation out of the biological context and turned it into the cornerstone of his genetic epistemology (Fosnot, 1996). He positioned two mechanisms to carry out adaptation. The first, assimilation, is a process used to incorporate new information into existing schemata that are sufficient to understand it (Bryant, 1996). In other words, it is the organization of experience with one's own logical structures or understandings (Fosnot 1996). What this means is that when someone encounters something new, he or she will try to deal with it (that is, recognize it or react to it) by using an existing schema or action plan. As a result, the schema is not changed essentially, but it is expanded to include the new experience and the result of the reaction to it (Tuckman, 1979).

By contrast, Piaget's second adaptive mechanism - accommodation, is a process used to modify an existing schema in order to be able to understand information that would otherwise be incomprehensible with existing schemata (Piaget, 1972). This time the person having the new experience cannot deal with it by using an existing schema; none fits it closely enough. Hence that person must change an existing schema to create an essentially new schema in order to be able to make an adaptive response (Tuckman, 1979). This is like the concept of learning or problem solving. When what is known does not work in a given situation, something new must be tried.

Assimilation and accommodation are processes that help people to grow and adapt to their environment continually. Assimilation helps people make better use of the schemata they have and accommodation helps them to alter their schemata to fit new situations. Play is pure assimilation; imitation is pure accommodation (Bryant, 1996).

A balance or cognitive equilibration must exist between oneself and one's environment. In order to do this, people equilibrate, that is, they sometimes assimilate and sometimes accommodate in dealing with situations that they encounter. This is what motivates the

developmental process. Piaget describes this equilibration process, as a dynamic self-regulated behaviour, balancing these two intrinsic polar behaviours. Fosnot (1996:64), states; *"in order to understand fully the concept of equilibration, one must think of it as a dynamic process, not a static equilibrium. Equilibration is not a sequential process of assimilation, then conflict, then accommodation. Instead it is a dynamic 'dance' of progressive equilibrium, adaptation and organization, growth and change. As we assert our logical constructs on new experiences and information, we exhibit one pole of behaviours; our reflective, integrative, accommodative nature ..."*

Hence the respective cognitive psychology can be summarized as: the learner is an active processor of information with emphasis being on the internal mental situations, experience and knowledge of the learner.

2.3.2 Social Constructivism
On the other hand, the work of Lev Vygotsky and that of activity theorists such as Davydov, and Galperin inspire social constructivism theory in large measure. Vygotsky shared many of Piaget's assumptions about how children learn, but he placed more emphasis on the social context of learning (social constructivism perspective).

Piaget's thrust of argument was that equilibration and dialectics must both be invoked in order to explain both individual social systems. This dialectic between the individual and society, (that is the effort of social interaction, language and culture) on learning became the focus of Vygotsky's work. Vygotsky, like Piaget, believed learning to be developmental, but he differentiated between what he called 'spontaneous' and 'scientific' concepts (Fosnot, 1996).

In Vygotsky's social enculturation theory developed in 1978, learning is seen as an active and social process, occurring via a variety of development processes that takes place through the interaction of the learner with people in the environment and in co-operation with peers. The final goal of social enculturation is to internalise the processes that are

modelled through the social interactions that take place. When these processes are internalised a learner can independently perform, as an expert and in a way appropriate to his/her culture.

The spontaneous concepts as studied by Piaget – those that the child develops naturally in the process of construction 'emerging from the child's own reflections on everyday experience', Vygotsky defined them as pseudo concepts. On the other hand Vygotsky proposed that scientific concepts originate in the structured activity of more logically defined concepts than those constructed spontaneously. He perceived them as culturally agreed upon, more formalized concepts (Fosnot, 1996). Thus one of Vygotsky's main questions became: What facilitates the learning that moves the child from spontaneous to scientific concepts?

In trying to answer his questions he came up with: *'the zone of proximal development'*, which is the range of potential each person has for learning, with that learning being shaped by the social environment in which it takes place. Vygotsky argued that scientific concepts do not come to the learner in a ready-made form. They undergo substantial development. He believed that the scientific concepts work their way 'down' imposing their logic on the child and meet spontaneous concepts, which work their way 'up' allowing the learner to accept its logic. He used the term 'zo-ped' (zone of proximal development), to describe the place where a child's spontaneous concepts meet the 'systematicity and logic of adult reasoning'. This zone varies from child to child and reflects the ability of the learner to understand the logic of the scientific concept (Fosnot, 1996).

In Vygotsky's views, learning takes place in a zone of development (see figure 4 below). This is the zone that lies between what learners already know and what they do not know, and between what they can and cannot do. The zone of proximal development is the zone

where the learner is just able to perform a task but needs to be supported. This gives an indication of what a student can do independently in the future (Vygotsky, 1978).
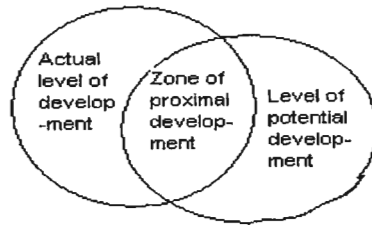
Figure 5: Vygotsky's zone of proximal development

In Vygotsky's own words (1962) cited in Fosnot, (1996:71)

"Through scientific and spontaneous concepts in reverse directions, the two processes are closely connected. The development of a spontaneous concept must have reached a certain level for the child to be able to absorb a related scientific concept...in working its way upward, an everyday concept clears a path for the scientific and its downward development. ...Scientific concepts, in turn, supply structures for the upward consciousness and deliberate use. Scientific concepts grow downward through spontaneous concepts; spontaneous concepts grow upward through scientific concepts...."

The challenge here is for the course facilitators to find a balance between the zone of actual development and the zone of potential development. A problem will occur if either is too deep. This is a delicate balance, as the position and width of the zone may differ per learner. This can be achieved through scaffolding; the process of providing and retreating of support. The concept of scaffolding and how educational resources can be designed to support it is discussed further both in this chapter and in Chapter 4.

Piaget saw *'Inner Speech',* as egocentric in nature (learners speaking to themselves), while Vygotsky on the other hand, saw speech as a social right from the beginning. He proposed that spontaneous concepts have two components, a concept-in-itself and the concept- for - others, with these two components providing a dialectic tension right from the start, as the child struggles to represent concepts in action with culturally appropriate symbols in order to communicate with others. This process prepares the way for the zone of proximal development.

'The dialogical nature of learning'- whereas Piaget sought to study and illuminate the role of contradiction and equilibrium in learning, Vygotsky sought to study dialogue. He was interested not only in the role of inner speech on the learning of concepts but also on the role of the adult and the learners/peers as they conversed, questioned, explained and negotiated meaning (Fosnot, 1996). Social constructivism emphasizes the importance of dialogue in learning. This learning takes place as an active process of constructing meaning.

'Semiotic interactionism': - the role of symbolic representation. Even though Vygotsky's representation of the zone of proximal development and scaffolding have somewhat been problematic to constructivists, his notion of the dialectical interplay between symbol and thought in concept development provided a fertile ground for research.

Learning is now first seen a social activity after which it will become an individual activity. People construct reality through interaction with others and learning is defined by the construction or reconstruction of knowledge (McLoughlin and Luca, 2003). Learning can be more effective and more productive if students work together to exchange ideas, compare information, solves problems and debate with each other.

2.3.3 Constructivist approach and use of computers in learning

There has been a lot of work in attempting to make computers in education match the constructivist ideal of learning through experience. For example simulations, hypermedia and adaptive learning systems all attempt to make the student learn through action. There is a shift in focus in the school curriculum concentrating on imparting thinking and life long learning skills. Fapojuwo (2003) puts forward that this is to ensure that learners, who will be the future workforce for the knowledge-based economy can be competent and independent. In the Dewey's process of doing and undergoing, the rapid development of the computer industry itself is probably the best example of the potency of this kind of computer-based educational experience. Many computer professionals are either partly or mostly self-taught. The growth in numbers of home computer buffs and hackers has occurred for much the same kind of reason: you do something to a computer, it does something back, and thus you learn. A computer is a fundamentally interactive device; input something and it outputs something in response for example during hands-on problem solving such as computer games and puzzles.

With the use of computers new ways of providing learner support could be found (McLoughlin, Winnips and Oliver, 2000), such as the use of computers in open discussion forums among students. Computer-based media that can be used in this scenario include chats, instant messaging, video conferencing and virtual worlds. Computers can also be used to solve real-life, practical problems. This is because they are multimedia tools. With integrated graphic, print, audio, and video capabilities, computers can be effectively used in constructing knowledge.

2.3.3.1 Cognitive constructivism strand and the use of computers in learning

To apply Piagetian principles to the use of computers in education, teachers/facilitators would organize the learning environment into learning centres (virtual classrooms) to facilitate discovery learning and creativity – the fundamental principle of cognitive constructivism.

Computers can also be used to feature the use of themes or integrated, interdisciplinary topics as a vehicle for teaching subject-matter-type skills. Moreover, Shanti (2003) argues that information should be child-centred rather than either curriculum or teacher-centred, and it should make great use of both individual and small group (online discussions).

2.3.3.2 Social constructivism strand and the use of computers in learning

If Vygotsky is correct that children develop in social or group settings, the use of technology to connect rather than separate students from one another would be very appropriate. Computers provide essential tools with which to accomplish the goals of a social constructivist classroom. The computer can be used to facilitate interaction among students; this is by designing programs that emphasize interaction between learners and learning tasks. Likewise, McLoughlin, Winnips and Oliver (2000) argue that computers can be used to shift the balance in interactions between teacher and learners. Most of the social constraints, which are present in face-to-face classroom settings, may not be present in a computer-supported learning environment, thereby providing more equal opportunities for students to initiate interactions such as online collaboration.

Examples of learning environments based on the social constructivist strand can be knowledge-building communities. The goal of knowledge building communities is to support learners to actively and strategically pursue learning as a goal - that is, intentional learning (Scardamalia and Bereiter, 1996). Learning using computers can be a very successful way of creating an intentional learning environment, where learners learn collaboratively as a knowledge building community.

Another example of applying social constructivism using computers is by anchoring of learning tasks environments in which the learners are presented with a problem that is embedded (anchored) in a real-world context. Examples are similar to those given in Section 2.3.3.1.

With appropriate adult help, computers can also be used to assist children perform tasks that they are incapable of completing on their own (scaffolding and zo-ped). Laat and Laaly (2003) sees this being achieved through delivery of learning tasks linearly/hierarchically or pseudo-linearly. Similarly it is possible to give more individual attention to a larger number of learners than in the ordinary face-to-face learning environment.

Some of the computer tools that can be used to support social constructivism include: CMC tools such as e-mail that provide a means for dialogue, discussion, and debate, interactivity that leads to the social construction of meaning. Lewis (1996) suggests that proponents of CMC promote the philosophy of the constructivist approach, using cooperative learning, collaborative problem solving and project based learning (PBL).

The philosophy is based on three basic characteristics stemming from Vygotsky's social constructivist theory. That is knowledge is not a product to be accumulated but an active process in which the learner attempts to make sense of the world. People conditionalize their knowledge in personal ways; they acquire knowledge in forms that enable them to use the knowledge later. The construction of knowledge is based on the collaboration and social negotiation of meaning. Common understandings and shared meanings are developed through interaction among peers and teachers (Alexander, 1999).

Some people argue that the personal computer is to Piaget, while the WWW is to Vygotsky. This is because with the onslaught of personal computers came the popularity of constructivist approaches to educational technology, where open-ended environments provided individual students with tools to experiment and build their own learning constructs. In the last few years, as the Internet and WWW have matured; the social aspects of learning as described by Vygotsky have become useful for those looking to design educational projects involving a distributed but intercommunicating audience.

Computers can be very important in supporting reflection and articulation thereby enabling the learners to share reflections among themselves, for example through asynchronous CMC tool. Reflective behaviour could be promoted by having students write daily or weekly journals on their educational experiences. These can be electronic journals from where they could extract information to write comprehensive reflective statements at a later date. Collins, Brown and Newman (1989) view reflection as a communicative process through which individual and shared meaning is constructed. This concept of reflection involves looking over what one did and analysing one's own performance. They further argue that when learners reflect on their actions they can develop metacognitive skills (learning how to learn).

2.3.3.2 Implications of constructivism approach on design and evaluation of OLS

In the last few years, as the Internet and WWW have matured; the social aspects of learning as described by Vygotsky have become useful for those looking to design educational projects involving a distributed but intercommunicating audience (Huitt, 2001). Complexity of online learning environments should therefore be based on a conceptual framework utilizing constructivist elements. When students are taught to use themselves as the ultimate learning tool then they can achieve great things.

The three stages of learning described by Brunner can aid educational software designers in designing software that has a relationship with authentic elements. The reason for this can be drawn from Piaget's notion of adaptation. That is, users' discovery and manipulation of the resource would involve an internal reorganization and association of previously known ideas in order to establish a better fit between those ideas and regularities of an encounter to which the learner has had to accommodate.

Hung (2001) applies Vygotsky's theory to HCI design principles of web based learning and establishes connections between principles drawn from Vygotskian thought and design considerations for web-based learning.

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Table 1: Application of Vygotsky's perspective in web-based learning environments

Vygotsky	Web-based learning resource
Learning is demand driven -dependent on engagement in practice	A web-learning environment should have a personalized content for the learner.
Learning is a social act between social beings through language, signs and tools.	Relates to such considerations of design as social, communicative and collaborative dimensions of web learning.
Learning is embedded in rich cultural and social context - acquiring both implicit and explicit knowledge.	Hung suggests that a web-based learning environment should allow learners to access learning materials in the local context
Learning is to transfer knowledge from one situation to another, discovering relational and associate meanings in concepts.	This concept is related to a web-based leaning environment that facilitates learning through observation of visual objects.

From the above table we realize that Vygotsky's social perspective can be well applied in computer based learning environments. For example, in a social environment students can learn to analyse their audience, design, develop and implement production. While managing their projects the 'class' as a team can learn web authoring, digital and analogue video production, for instance in the modules offered in the postgraduate degree program in Digital Media, University of Natal, through collaborative learning the students have been able to develop knowledge and skills in a number of fields related to the design, development and use of digital technologies in research, e-commerce and education.

Therefore, efforts will be made to establish and investigate whether OLS is actually grounded on constructivism epistemology. Similarly, OLS constructivism perspective (individualistic or social perspective) will be determined. Also the tools, elements and design characteristics of the system that allow for construction of knowledge will be established and investigated.

2.3.4 Rich Environment for Active Learning (REAL)

Rich learning environments can be viewed as those that allow for different learning styles, those that allow for collaboration and authentic activities and those that allow for interaction, for example Computer- Mediated Communication tools.

2.3.4.1 Authentic Learning Contexts

Authentic learning experiences are those which are problem or case-based, that engrosses the learners in situations requiring them to acquire skills or knowledge in order to solve problems or manipulate situations (Jonassen, Mayes and Mc Aleese, 1993).

Authentic learning experiences immerse the learner in a culture much like an apprentice (Young, 1993). These types of activities reflect the experiences of real-world practitioners, which may assist student learners to transfer knowledge into real-world settings. The concept of authentic cases, authentic learning experiences and embedding knowledge and skills in a realistic setting have a long history to philosophers like Dewey, Piaget amongst others (Keppell *et al.*, 2003). These complex tasks bear a strong resemblance to tasks performed in non-school settings (Mueller, 2003).

Students can be assisted in this complex learning environment by providing them with online samples of past projects, employers' perspective and server space for hosting their projects.

The following ten characteristics of authenticity by Reeves, Herrington and Oliver (2002) can guide online course facilitators when creating an authentic task. These characteristics suggest that authentic activities; have real-world relevance; are ill defined and require students to define the tasks and sub-tasks needed to complete the activities; comprise complex tasks to be investigated by students over a sustained period of time; provide opportunities for students to examine the task from different perspectives, using a variety of resources; provide the opportunity for collaboration and reflection; can be integrated and applied across different subject areas and lead beyond domain-specific outcomes; are

seamless integrated with assessment; create polished products valuable in their own right rather than as preparation for something else and allow activities competing solutions and diversity of outcome.

Although it is almost impossible to design truly authentic learning experiences (Reeves, Herrington and Oliver 2002), there is a strong case for designing learning experiences that will enhance or compliment professional practice.

As an example, in one of the modules called Internet and Databases, in the Digital Media program of the University of Natal, students were provided with guided questions, activities and server space, which allowed them to explore, using simulations of databases. The tasks given were complex and challenging in nature, which enabled them to familiarize, extend and integrate the knowledge gained to other stages associated with database design and management.

2.3.4.2 Computer-Mediated Communication tools (CMC)

Computer-Mediated Communication (CMC) refers to human communication via computers including computer network communication on the Internet and the World Wide Web. In other words it is the transmission and reception of messages using computers as input, storage, output, and routing devices (Alexander, 1999).

However there have been continued debates on whether media influences learning. For example, Clark (1991:34-40; 1994:21-29) argues, *"... Media does not influence learning under any conditions"*. The best current evidence, he notes; *"is that media are mere vehicles that deliver ... but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition."* Kozma (1991; 1994; undated) in the same online debate challenged Clark's division between media and methodology claiming that this creates *"an unnecessary and undesirable schism between the two"*. He suggested moving the question to how we can use interactive learning for

particular students with specific tasks in distinct contexts. He argues with Clark that interactive technology may be essentially the delivery vehicle for the pedagogical dimension; however some vehicles are better at enabling specific design than others. He sums this by stating *"understanding the ways in which students use the unique processing capabilities of the computer (or other media) is essential to understanding the influence the computer may have on learning and to building media theory"*. In this debate it is evident that both Clark and Kozma present very important ideas.

Johnstone and Krauth (1996) claim that research on the effect of CMC has been focused on student outcomes but not on the affective aspects of distance education. On the other hand Papert (1993) claims that it is in the way the computers are used that will make a difference. On the contrary, Forsyth (1999) suggests that it is important to do Strength, Weaknesses, Opportunities and Threats (SWOT) analysis of using the Internet as a delivery tool.

With such ongoing debates and discussions it is evident that CMC tools are part of a rising technological tide that began with computers and gained momentum with networks, most notably the Internet. These tools enable communication across time and distance with other networked computer users who have similar tools. Internet connectivity allows students to communicate with a potentially global audience. Students can use these tools to supplement their learning activities, through communication with course facilitators and fellow students or by supporting collaboration. This can open more possibilities for distance educators to overcome time and distance to reach students. The communication can either be synchronous or asynchronous. A number of these CMC tools have been used to facilitate student interaction and evaluation. Schrum (1996) states that students find that greater reflection is required when typing, than when speaking.

2.3.4.2.1 Asynchronous communication

Asynchronous communication provides time for reflection and composition. For instance reading email or bulletin board postings encourages reflection. It is relatively simple and inexpensive to implement. It is characterized by the lack of sequence. If you post a discussion message to an asynchronous discussion group each of the group members will only have the messages when they log into the system. One may send a message in the morning, but there is a fair chance that most will not read it immediately. This time delay between when one sends a message and when others read it is the defining characteristic of asynchronous communication. Therefore this type of communication provides efficiencies, especially with groups, which are geographically and physically separated (for example in different time zones). Additionally, in a learner-directed constructivist environment, asynchronous communication emphasizes learner independence.

Asynchronous communication systems include: email, bulletin boards or newsgroups. They can mimic, albeit in an awkward fashion, synchronous distributed interaction should multiple users decide to log in at the same time.

Electronic mail (E-mail) can facilitate collaborative learning among the learners. In distance learning, feedback from the course facilitator can be received more quickly than messages sent by post. E-mail offers the ability to communicate outside the barriers of time and space. Students can read messages at their convenience and easily store them for later reference (Shay, 1995). Students can fill out forms created as a link and email them to the relevant person thus, saving time and cost of posting hard copies. The *bulletin board* also referred to as newsgroup, can be used for collaborative learning. Distant students often work in isolation without the assistance and support of fellow students. Setting up a virtual place for students to pin messages can encourage student-to-student interaction.

Discussion forums also called web discussions learning environments over the Wide World Wide (WWW), which have drawn a great interest in education. In a conference in Durban,

South Africa, Fahraeus (2003) shared the result analysis on her PhD paper "How students see group and learning processes in asynchronous e-discussions". Some of the interesting conclusions drawn from this study were that although it took time and effort to develop the skills to learn through e-discussions, the students got to reflect upon their processes thereby learning from this and got an opportunity to build a group identity and developed shared values which enabled them to create a cohesive learning community.

2.3.4.2.2 Synchronous communication

Synchronous communication and collaboration tools, such as synchronous text chat, audio-conferencing, video-conferencing, and whiteboards, are increasingly important components of CMC. Although traditional classroom lectures are synchronous, they do not tend to be interactive because information usually flows in only one direction - from the lecturer to the students. Traditional classroom discussions, on the other hand, are often interactive but, like lectures, they are not distributed spatially. Synchronous distributed interaction requires a networked environment in which users can transmit messages simultaneously from different places.

Interactive Videoconferencing (IV) is an effective tool that may be used in distance education settings. This can be viewed as an electronic meeting. However, the initial cost of the equipment and leasing the lines to transmit conferences may be prohibitive. *Chat* is a synchronous system in which users can interact in real time by typing text. Internet Relay Chat (IRC) is the most common chat program. It uses channels to transmit text between groups of users. Users need a chat client software program to connect to an IRC server and select a channel. Chat system can be used in online learning where learners meet in a virtual classroom for discussion.

The advantages of chatting include: it is instantaneous and gives the learners the feeling of closeness. This can take place between groups of people (students and course facilitator) who in online learning can form part of motivation. The disadvantages of chatting include

being expensive especially for a distance student who is using private Internet facility and may face the problem of complex and non-standard user interfaces. Also chat might disadvantage those students who are slow in typing and those on a slow connection always lag slightly behind in the discussion. Similarly discussions may tend to lose focus because of too many side discussions and the problem of the responses getting out of sequence, the reason being the need for simultaneous user attention in multiple areas (that is, message composition and message monitoring).

2.3.5 Implications of REAL on design and evaluation of OLS

More recently, attempts to enhance cognition in authentic learning-performing tasks have become widespread. We can create a context within which knowledge is anchored to authentic contexts by designing a user centred learning environment (Wlodek, 2003). This effective learning environment would enable learners to use its resources and tools to process more deeply and extend thinking.

Designing learning environments that include authentic tasks and provide collaboration can be achieved by: *providing an authentic learning* context that grounds the students in the real life circumstances, for example by providing simulations; *designing user-centered learning resources-* learners can have the opportunity to construct and reconstruct concepts in personally meaningful ways when interacting with user interfaces that give them the opportunity to experience complex, integrated and rich environments; *designing learning resources that provide an environment for situated learning.* This is because situated learning supports that for knowledge to be active it should be learned in a meaningful context and through active learning. Young (1993) suggests that an active relationship between an agent and the environment, and learning must take place during the time the student is actively engaged in a complex, realistic context; *anchoring knowledge* in an authentic contextualised learning environment and around an interesting topic. These learning environments can be designed to provoke the kinds of thoughtful engagement that helps students develop effective thinking skills and attitudes that contribute to effective

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problem solving and critical thinking (Mueller, 2003); scaffolding - by providing 'real life' situations, this can act as a scaffold to the learner. Encouraging the students to engage with the content and synthesize ideas in their own words are good examples of authentic activities. Designing educational software that offer simulation capabilities can also help in this. McLoughlin, Winnips and Oliver (2000) describe potential forms, tools and applications that can be used for web-based learning. These are: email, threaded computer conferencing, frequently asked questions, hyper linked resources, collaborative workspaces and online chat.

Designing software that allows for a REAL environment can also be achieved by providing a holistic approach to learning. This is an environment that aids learners to appreciate and integrate what they have already learnt, comparing, contrasting, finding interesting themes and evaluating one another's tasks. This can be achieved by incorporating learning tools like the discussion forum, chat and video conferencing for learners to embed the learning environment with collaborative activities.

REAL environment can also be achieved through designing educational software that allows for the use of authentic tasks in multiple perspectives. Koschmann *et al.* (1996) argues that if students are provided with a singular perspective, they may oversimplify concepts that may ultimately prove misleading. Similarly, it can be achieved by providing tools that best align the tasks and provide seamless, continuous assessment. For example, portfolio submission and peer review tools (Wlodek, 2003), and by designing educational software, which allows the learner to learn by exploration (experimentation). Assimilation and accommodation require an active learner, not a passive one because problem-solving skills cannot be taught, they must be discovered.

Figure 6 shows how various elements that are encompassed in REAL, constructivism epistemology and software design can be embedded together in context and in the hub of technology in evaluation of educational software.

The Hexa-C Metamodel (HCMm) (de Villiers 2002), is a framework of interrelated elements of contemporary learning and instructional theory, and it is so called because its six elements all start with the letter 'C'. de Villiers (2003) posits that it can used as design aid for teaching and as a six-sided approach for evaluating existing learning resources environments, investigating whether and how its elements are implemented in the system being examined. These elements are - cognitive learning, constructivism, components, creativity, collaborative learning and customization as merging segments.
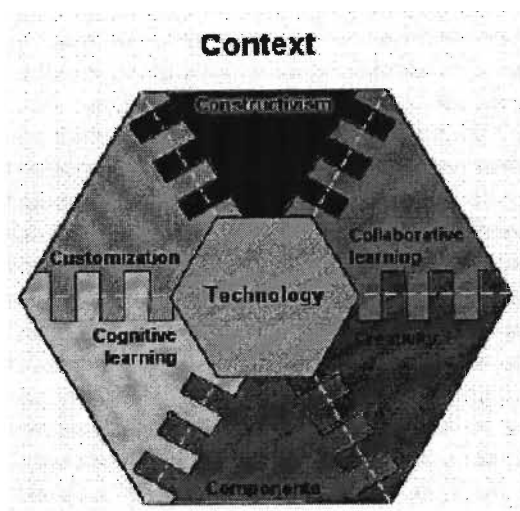
Figure 6: The framework of the Hexa-C Metamodel
(Reprint from de Villiers, 2003)

Therefore, efforts will be made to establish and investigate the tools, elements and design characteristics of OLS that allow for REAL environment.

2.4 User-Centred Design (UCD) approach

UCD ensures that users are involved during the entire development of a product. The UCD approach relies on specific types of analyses to reveal the conceptual, design, and development information relevant to user needs, strengths, limitations, and behaviours. These types of analyses often include task analyses and usability testing, although several other methods of data collection and analysis are used. In addition, the user-centred software design approach adheres to user interface standards that ensure the same types of

actions and displays in one system have the same general meaning in other applications (The Human Factor Inc, 2002).

The primary objective of this approach is to reduce the cost of design defects and to meet specific usability objectives, by allowing user participation in the early design phases. This is attained through the iterative nature of user-centred design and some of the general categories of techniques and methods[1] that may be used. The term coined for this approach, namely UCD, appeared in 1986, as the main title of an edited collection of papers on the topic (Norman, 1986). Lynch and Horton (2002) adds on that the goal is to provide for the needs of all potential users, adapting web technology to their expectations and never requiring them to conform to an interface that places unnecessary obstacles in their paths.

The normative perspective of UCD is to fulfil the need for 'usability now.' By providing techniques that foster tight design-evaluation feedback loops, iterative prototyping, early design input, end-user feedback, among others. It places the person (as opposed to the 'thing') at the centre; it is an approach that focuses on cognitive factors (such as perception, memory, learning, and problem solving) as they come into play during peoples' interactions with resources.

In subsequent years, due to the compelling need to cost-justify usability throughout a product's life cycle, evaluation moved toward a variety of techniques, generally referred to as inspection-based evaluation, which, though inexpensive, are less formal in their conduct and deliverables (Nielson, 1993). The experiences have given rise to a generally applicable process model for constructing human-centred systems.

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[1] As pointed out by Demosthenes, Dimitrios & Constantine (2001), the techniques and methodology include Traditional Human Factors experiments, Performance measurements, and Subjective assessment and Conformance testing.

UCD can improve the usability and usefulness of everything from 'everyday things' (Norman, 1986) to software, to information systems to processes, anything with which people interact. As such, UCD concerns itself with both usefulness and usability. Usefulness relates to relevance; do the functions, information, match what the user actually needs? Usability relates to ease-of-use, a simple concept, but not always easy or intuitive to implement.

With the UCD approach in mind some of the guidelines that would ensure that educational software is responsive to the needs to the users include:

Pedagogical issues – educational software must use proven and effective techniques that address the needs of the audience and address general pedagogical issues such as appropriateness of the computer, methodology, accommodate individual learning differences and promote collaborative learning (Reeves, 1993). Where possible, educational software should adapt to the learner's skills and knowledge.

Motivating the learner – a good design should be aesthetically pleasing and technically innovative, as this attracts and holds a user's attention.

Requiring active involvement – educational software should be designed in such a way that it will increase the possibility of learners' actively processing information (Forsyth, 1999).

Providing guidance and feedback – between and among the learners and the module facilitators.

The issue of accessibility – some basic needs of users with different disabilities should be addressed, such as navigational elements, search functions and site map. 'Chunk' information into small, digestible pieces and organize them into some type of schema or hierarchy that is meaningful to the user (Truchard and Raïssa, 2001). Specific solutions for designing more accessible software if necessary can be addressed depending on the intended audience. For example, Stephanidis (2001) reviews recent efforts and experiences towards user interfaces for all, a concept introduced to serve the goal of design for all in

HCI, and outlines the unified user interface development method for constructing user interfaces adaptable to the individual abilities, skills, requirements and preferences of the end user. He advocates that the adoption of design for all principle in the development life cycle necessarily entails proactive measures.

Language – usability can be improved by incorporating the following stylistic elements: concise language; everyday words instead of jargon or technical terms; active voice and active verbs; and simple sentence structure (Truchard and Raïssa 2001).

The Human Factor Inc (2002) further provides some more guidelines that need to be considered in a system.

Grouping – this includes: frequency of use (ordering or grouping objects based upon how often a user will access them); importance of use (grouping objects based upon how important the object is in an overall user task); sequence of use (ordering objects based upon the sequence a user needs to manipulate them); and functional grouping (grouping of objects based upon logic).

Standardization – this helps users to apply what they have learned in one application to another. Items that could be standardized include: labels, icons, mnemonics, widget or control layout among others.

Layout – this includes: clutter (displaying too much information to the user at a single time or in a single place); grouping (grouping objects based upon frequency, importance, sequence, or function); consistency (arranging widgets consistently throughout the UI); and optionally providing a brief description to direct users in their task.
Labelling – this should be meaningful and distinctive. It should work with any input device. Consistency should be observed especially in capitalization and use of units.

Figure 7 below is a sample of the international standard for UCD iterative evaluation - the basis for many UCD methodologies; this standard (ISO 13407: Human-centred design process) defines a general process for including human-centred activities throughout a development life-cycle, but does not specify exact methods. Therefore all the elements discussed above will be considered in the overall evaluation of OLS.
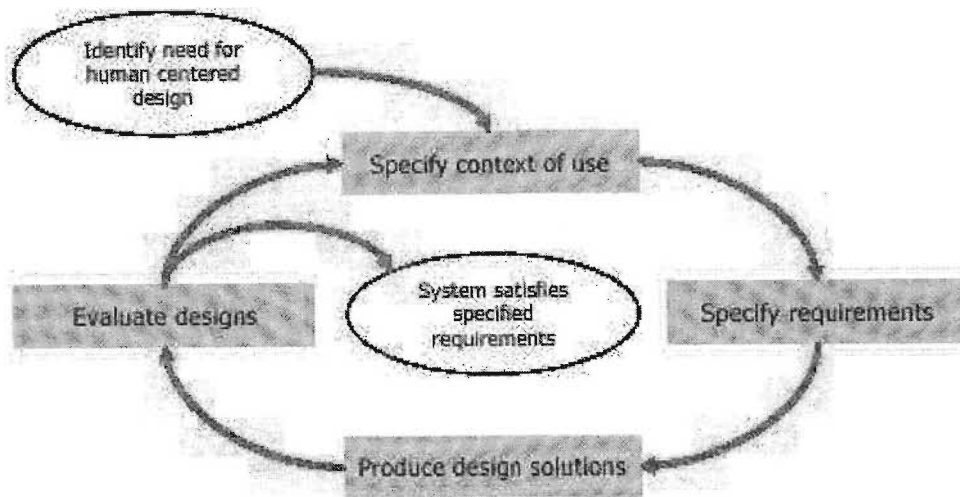
Figure 7: An iterative evaluation process.
(Reprint from Usability professional association, 2003)

2.4.1 Implications for User-Centred, Iterative Design on OLS

The field of designing educational software is complex and rapidly changing. The knowledge and skills involved is partly explicit and partly implicit. According to Nelson (1994) designers should not be too concerned with 'predictability and control', but they should choose to be 'thoughtfully out of control'. Rowland (1992) speaks of a balance between rationality and intuition, technical proficiency and creativity. With this in mind it can be concluded that while part of design activities can be described beforehand (explicit), a part cannot be described beforehand (implicit). Therefore it is important to evaluate designs to determine both implicit and explicit parts. A learning resource cannot just follow a predetermined path, but it has at least partly to be based and centered on the user needs, hence UCD.

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Therefore, efforts will be made to establish, investigate and determine whether OLS is user centred or design centred.

2.5 Human computer interface design principles

Several authors in the HCI literature have proposed guidelines and models for good design features (Vassiliou, 1982). While no definitive set exists, there is a certain consensus and the following features are in distillation of recommendations by several authors.

Designing educational software is an interesting challenge. The goal is to produce a learning resource that is both fun and educationally beneficial. Thinking of a computer program that is educationally beneficial is not too difficult. But making that resource appealing at the same time is no small challenge. Assigning print strategies to a web layout is disastrous in web design because many of the rules of print simply don't apply to the web.

Nielson (1993) suggests that there is no ideal measure of a good interface but some ideas are beginning to emerge about what are the important qualities of an interface from the users' point of view. The qualities have been christened with terms such as 'acceptability' and 'usability'. He suggests the following components:

Utility - this is a measure of how well an interface helps the user to perform one or more tasks. It is linked to the functionality of the system (what you can do with it) and the task fit, for example, how well does the interface facility provided match what the users want to do and their perception of how to do it (the task). This is difficult to measure. Attitude data from questionnaires can give some feel for task fit, but more comprehensive analysis requires elucidation of a user task model.

Effectiveness - this is a measure of how well the interface, and hence the system, performs in achieving what the user wants to do. This can be measured in terms of error rates lower

than a target level; task completion time with a set target time and usage of system facilities above a minimum target frequency. The system should be easy and efficient to use, so that once the user has learned the system, a high level of productivity is possible. Nielsen (1997, 2000) discusses other important principles, which are:

Memorability - the system should be easy to remember so that the casual user is able to return to the system after some period of not having used it, without having to learn everything all over again.

Errors - the system should have a low error rate, so that users make few errors during the use of the system (also known as error prevention principle). Error messages should indicate the cause and/or the cure for the error. Error messages are for the benefit of users not developers, so diagnostic errors should be removed. Therefore the error messages should be in the form of short clear sentences. Use of jargon should be avoided as well as emotional words or phrases such as 'Sorry', 'Too bad', among others.

Satisfaction - the system should be pleasant to use, so that users are personally satisfied when using it.

Five basic rules of web page design and layout by Grantastic (2003) can also be very helpful educational software designing principles. These rules are: the software should be easy to read; easy to navigate; easy to find; consistent and quick to download.

2.5.1 Readability
This is one of the most important rules in web design. Issues to consider here include:

Resolution of a display monitor is the total number of pixels used to display the picture. A pixel is a single dot of light on a display monitor. The more pixels used the better the resolution and therefore the quality of the picture.

It is important to keep the page content of online learning software to fit on the screen so that visitors do not have to scroll down and horizontally to find the information they want (Austin, 2001). In an online learning environment this is very important as it also frees the learner from vertical scrolling. However, this is usually not possible, but can be attained by: keeping the page length as short as possible, using links, using index pointers – this is simply any text or graphic link which when clicked takes the learner/visitor to the corresponding part of the page and having a top link button to allow users to move back to the top.

Typography – the harsh reality of web design is that a designer does not have the kind of control over how the text appears. Font style and size, where the text breaks, and how the text reads – are all aspects of typography. On a web page, they are mostly determined by the web browser and not by the creator or owner of a web site (Grantastic, 2003).

Fonts – conservative use of fonts is very important. This is because what the users will see will be determined by the display on their computers. It is best to keep a font convention throughout the web site (Bearman, 1997). Cascading style sheet (CSS) technology can allow for setting up a special set of font styles, which can be used consistently through out the site.

In an online learning resource, font is a very important element, which can affect readability. Headings can be used to provide visual cues to the learners. It is important to choose a typeface that is appropriate for the content of the page. Forsyth (1999) observes that this can influence how the online learners read the text.

Text layout – when laying out blocks of text, there are two important decisions to be made: line length (the length of the text) and line spacing (the distance between the bottom of the characters on one line and the next). This too, affects readability. In general, text lines

should be about eight to twelve words long. This can be applied by using appropriate margins and increasing line spacing to make text easier for online readers.

Layout sketching – one can achieve a better page layout by adopting the Hypertext Markup Language/ Cascading Style Sheets (HTML/CSS) creation process. For example, many people begin by sketching possible layouts on paper, or in a graphics program (Marshall, 2001).

Colours – technically, it is possible to produce millions of colours on the screen, provided the monitor and video display are of decent quality (Grantastic, 2003). However, there are actually only 216 web-safe colours - meaning that these are the only colours that appear the same on all monitors and operating systems without dithering.

Colours should be used conventionally. The reason being that they can engage online learners, both emotionally and cognitively and add visual interest to the site. Misapplication of colour creates negative outcomes. 'White space' can be used to visually organize the pages, to make important elements stand out, and to give users' eyes some resting space. Poor use of colour seriously affects ability to read documents (Gillespie, 2002). For online learners browser-safe colours should be used.

Also, too much colour on a web page can be distracting and counterproductive. Many colourful items can also create a visual effect equivalent of noise (Grantastic, 2003). The most successful strategy in designing for online learners is to use colour sparingly. This can help the learners focus on the items that are highlighted in colour as being of priority.

Colour schemes – schemes can vary in complexity from 'black for text, white for background', plus an additional colour for highlights. Although most people choose colour schemes 'by feel' and randomly, some acceptable guidelines can be helpful. For example, red conveys warmth, blues and greens are cooler, pastels can give a light and airy feel to a

site while dark and strong colours can encourage a powerful impression (Marshall, 2001). The examples in figure 8 show the difference choice of colour can make. Colour should be used to enhance the content of the screen. It is better for a screen to be too plain than for it to be unreadable.
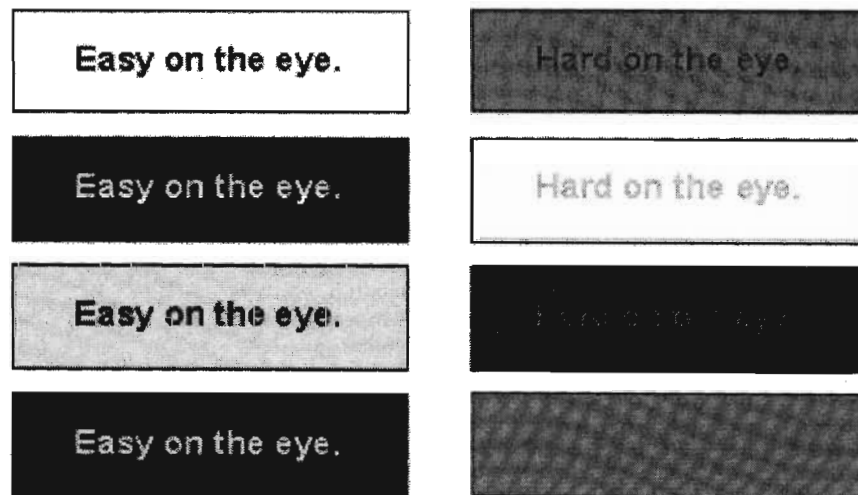
Figure 8: Text and Background Choices

Plug-ins can be used to enable the users to view the site with the designers' topology preference. This is a software extension that provides added capabilities to the browser (Grantastic, 2003).

2.5.2 Graphics

Another important principle in the HCI literature is the appropriate use of graphics in educational resource. Studies have indicated that visitors will quickly lose interest in a site if the majority of a page does not download within fifteen seconds (Grantastic, 2003). It is best to keep download time as short as possible. This can also affect the Internet connectivity costs for the distance learners.

The issues that can be considered here may include:

Images - can be used to add some content, style or interest to a site; however they should be appropriate to the content of the page and fit with the colour scheme among other things (Marshall, 2001). Images should be used to illustrate and inform users and not exclusively for decoration. They should have an alt label and every graphic link should have a matching text link (Nielsen, 2000).

For online learning these images should have a purpose either purely functional or contributing more subtly to the page content. A photograph of two students communicating, for instance can be used to indicate a communication channel. Images can also be used for learning, as illustrations or diagrams for a lesson and for navigation purposes. In an online learning environment, image size should be a major consideration as learners may face problems related to bandwidth or speed of the modem.

Animated graphics should be avoided, as they tend to be large files, thus slowing download time. They may also distract the readers (Gillespie, 2002).

A well-scanned image allows for the audience to perceive an added value in the site. For web images the smaller they are, the better and the quicker they download. This has very little to do with physical size of the image on-screen, it is purely a function of the number of bytes of data that have to be transferred from the server to the client machine (the file size). This can be attained by saving an image in an appropriate format and with fewer colours (Gillespie, 2002). Any image larger than 35k is questionable for use on the web, while images larger than 50k can rarely be defended.

Some of the images that can be used in a learning resource include:

An image map – an image map is a single graphic image that allows users to access different web pages by clicking on different areas of that image (Grantastic, 2003). Image maps can be a creative way for navigating a site.

Navigation buttons – they can be used to help visitors navigate the site. If designed well, these buttons can be much easier to read and find than text links.

Logo – this is a symbol that serves to identify an institution, a department, a virtual classroom or an organization. In online learning, consideration should be made as the use of a logo takes up both screen space and bandwidth every time a student accesses the site.

Bullet points – in an online web page, bullet points can be used to draw the learners' eyes to the main points of a document. They are also used to break up a web page full of paragraphs.

Mastheads – also known as a title graphic. They can be used to let the learners know which web page they are on. Adding clips art or an illustration to a masthead adds more visual appeal.

Divider lines or horizontal rules – can be used to separate footers, categories within a single web page, and Frequently Asked Questions (FAQ) and answers.

Background images – used to enhance the visual appeal of the site and make a web site easier to navigate. One of the most common background images is a sidebar, which usually contains the links to the other pages in a site.

Headings (text graphic) – commonly used to preserve a typeface that many people do not have on their computers.

Photos – commonly used to make your web pages appear more personal and more inviting. Visitors' eyes are naturally drawn to photos of people.

2.5.3 Navigation

Navigation and Hyperlinks – link is a connection from one page to another within one website (on-site) or other websites (off-site) found important or interesting for the viewers. 'Navigation' is the process of clicking on the links that assist the viewer in moving from one page to another within a website, for example 'Home'. Good links facilitate navigation. They can be textual or graphical (Gillespie, 2002). Icons and buttons make ideal graphical links, as they are usually physically small, optimised for the web and load quickly. Navigation is one of the most important elements in designing a good learning resource. In ordinary circumstances one of the quickest ways to lose visitors in a site is when they are not able to find their way around the site or if they are not able to find the information that they require (Tognazzini, 1998). They should be able to find what they are looking for in the site within three clicks. If not, they are very likely to click off the site as quickly as they clicked on it. A screen is very different from a print media. One cannot assume the viewer has seen previous pages or will proceed to subsequent pages on the site. Each page must be able to stand on its own. Most user interactions with web pages involve navigating hypertext links between documents/pages. Lynch and Horton (2002) perceive that the main interface problem in web sites is the lack of a sense of where a reader is within the local organization of information. Figure 9 below shows a site with logical navigation while Figure 10 shows a site consisting of 'dead-end documents/pages' the reason being that the subsection pages do not contain links to the home page or to local menu pages.

First Web site

Hypertext link

Second Web site
(a sequence of pages)

(Users can move back and forth)
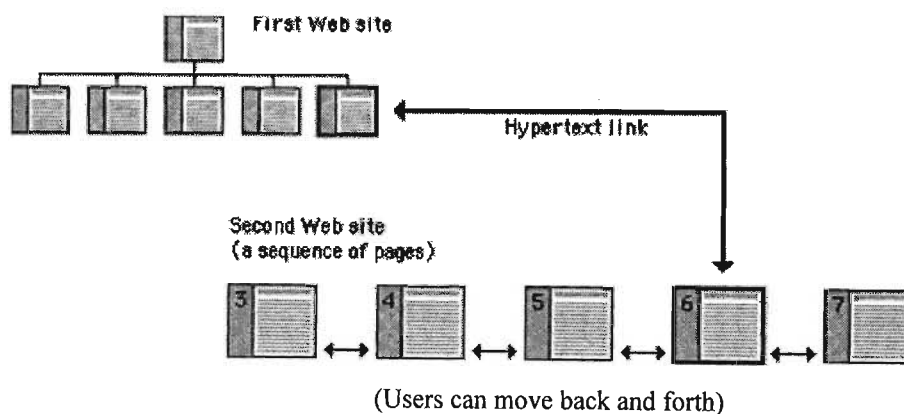
Figure 9: A site with a logical navigation
(Reprint from Lynch and Horton, 2002)

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"Dead-end documents"

Readers can link directly into pages deep within your site. If there are no links on a page, that page is a dead end.
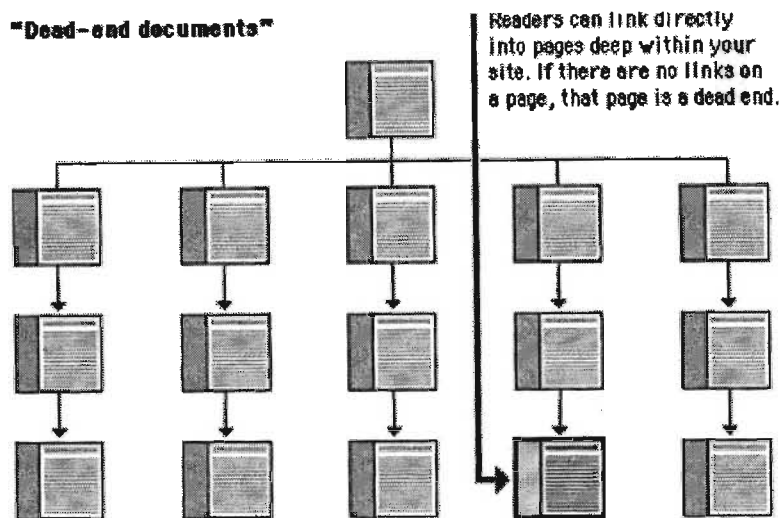
Figure 10: Site consisting of 'dead-end pages'

(Reprint from Lynch & Horton, 2002)

In choosing styles for navigational elements it is important to reach a balance between aesthetics and functionality. The question to ask is: if the users chose to switch off automatic graphics download, and some do, can the navigational scheme still work at a plain text level, or will they be lost at sea? Creating a distinctive visual style and applying it rigorously is the best way to hold a series of related, or disjointed, web pages together. A good navigational structure creates its own identity and boundaries. In navigation terms, you know when you are within the site and when you have left the site. Furthermore, it communicates a qualitative statement about the site or individuals responsible for it. On this Lynch and Horton (2002) emphasizes that a the user interface for a site should follow the general navigation and layout conventions of major web sites because most users are used to those conventions.

Links play a vital role in online learning. The origin of the Internet was to set up links between like-minded people, seeking and sharing information. Well constructed links and navigation allow the learner to move from one page to another in an organized manner and affect their metacognition skills (how learners learn to learn).

Graphic symbolism and navigation - one of the most important aspects of navigation, and interface design generally, lies in an understanding of graphic symbolism. That is, what the graphic represents or is associated with. For example, a house icon to represent a home can be understood fairly because it is recognizable through familiarity and is in context. Links should be descriptive enough so that users can easily predict what they will find when they click a particular link.

Navigation schemes - when designing an online learning resource, it is important to create a web site navigation scheme that is consistent throughout the entire web site and that allows the learners to find what they are searching for quickly and easily. A consistent site navigation scheme shows the learners that a designer was thinking about them during the planning stage.

Some of the basic web site navigation schemes that can be used in the page design of an online learning system include:

Text links colours- this should be familiar to the visitor where possible. Blue text usually indicates an unvisited link and purple or maroon text usually indicates a visited link. Otherwise text links can be emphasized in some other way for example, boldfaced or a larger font size (Grantastic, 2003). Text links should be unique - they should not look the same as any other text on the site. It is not fair for users clicking on the headings because they think the headings are links.

The advantages of using text links are: they are quick to download and some of the text can be keywords. While the disadvantages are, they can be boring to look at, especially if the site has large amount of blue links sprinkled throughout the web pages.

Graphic images - navigation buttons add uniqueness, colour, and personality to a learning resource. Advantages of using graphic images are: they add visual appeal to the site, as

long as the navigation buttons have alternative text in the HTML code, the site can still be navigated even if the users turn off the graphic images. While the disadvantage is that they may take long to download if the file size is too big.

Graphic images - image map: this is a single graphic image that allows users to access different web pages by clicking on different areas of that image. Image maps can be a creative way for creating a navigational structure for a site (Grantastic, 2003).

Advantages of using an image map for navigation include: sometimes a single image map is quicker to download than multiple navigation buttons, graphic designers can show a bit more creativity in designing an image map compared to designing a set of navigation buttons and alternative text can also be placed inside the HTML of an image map. One of the disadvantages of using an image map for navigation is that depending on size they may be slow to download.

A good model of interface design is the Adobe Corporation web site below (Figure 11). Graphic headers act as navigation aids and are consistently applied across every page in the site. Once the reader knows where the standard links are on the page header graphics, the interface becomes almost invisible and navigation is easy.

Figure 11: Adobe Corporation Web site - a good example of interface design

2.5.4 Consistency

Consistency is the similarity of patterns, which may be perceived in tasks, in presentation of information and other facets of an interface design. Consistency reduces the human learning load and increases recognition by presenting a familiar pattern. People have pattern recognition abilities, the more consistent patterns are, the less they have to learn, and the easier an interface will be to use.

All graphic images and elements, typefaces, headings, navigation, background footers and special effects should remain consistent throughout the site. Generally, every lapse from consistency can be perceived to have a meaning or reason. This can be used intentionally for example for highlighting important work. Nevertheless, unintentional use of these cues should be avoided (Marshall, 2001).

Tables can be used to enhance consistency. A HTML table is a grid of cells laid out in rows and columns. Each table cell can contain text, numerical data, an image or even

another table. Presenting information in a table is one of the simplest yet most powerful techniques available to web designers. Advantages of using tables include but are not limited to: ensures that neatness and order are demonstrated over a range of browsers; information can be presented over a precise row and column format; a variety of attributes can be applied to the tables and cells including: using different shades, applying or hiding borders, changing cell size, spacing, spanning and padding; tables provide the illustration that text, numbers and images can be positioned independently anywhere on a web page; the table background takes precedence over the web page background (Austin, 2001). Tables can be very important elements when designing an online learning web page; this is because information presentation will be enhanced.

Nielsen (1993) recommends that consistency improves the users' productivity by leading to higher throughput and fewer errors because the users can predict what the system will do in any given situation. It also strengthens users' expectations with respect to being able to use new software, leading to feelings of mastery and self-confidence.

Consistent software has a potential for leading to more aesthetic user interfaces because different aspects of the interface comply with a single underlying norm and because (presumably) it shows that significant human factors and efforts has been invested in design of the interface architecture.

Similar type/kind of information should be represented in the same location on all screens and dialog boxes and should be formatted in the same way to facilitate recognition. Consistency is not just a question of system design, but includes considerations of the task and functionality structure of the system.

2.5.5 Ease to locate

One way to make an online learning resource easy to find is by using a Uniform Resource Locater (URL) that is not too difficult for the users to remember. Not only should the site

be easy to find, but also contact information should be easy to find. Users like to know that there is a person at the other end of the site who can help them in the event that they need answers to questions which are not readily available on the site or that some elements on the site are not working and end users need to be able to report this.

2.5.6 Learnability

Learnability measures how easy to learn a system is, and how well it is remembered after a period of disuse. Nielson (1993) suggests that learnability can be quantified with measures of: decrease error rates over time from the start of system usage; decrease in task completion time from the start of system usage; correct recall of system facilities; operational procedures or command names; increase in user knowledge about system facilities over time.

2.5.7 Metaphor

Mandel (1997) defines a metaphor as a figure of speech in which a word or phrase denoting one kind of object or action is used in place of another to suggest a likeness or analogue between them. Metaphors aid users in understanding a new target domain (for example a word processor) by allowing them to comprehend it (up to the point of 'mismatch'...) in terms of source domain that they already understand (for example a typewriter). Metaphors aid designers because adoption of a metaphor allows them to structure aspects of the target system or interface in terms of familiar and commonly understood aspects of the source domain. Tognazzini (1998) notes that metaphors should be well chosen, so as to enable users to instantly grasp the finest details of the conceptual model.

Interface metaphors should be simple, familiar, and logical. A metaphor for information design should be a genre familiar to readers of the documents, such as a book or a library. Highly unusual, 'creative' navigation and home page metaphors often fail because they impose an unfamiliar, unpredictable interface burden on the user.

2.5.8 User autonomy or control

Constructivist learning environments allow for user autonomy. The concept of autonomy is that users have different capabilities for making decisions regarding the control of a system or a program. The higher the autonomy the greater the comfort the users derive. However, trade-offs do exist in the list of design goals and principles. First, they are often in direct conflict with one another. For example, increased ease of use might require sacrificing product compatibility across releases. Simplicity may require decreasing power and ease of use. Making trade-offs intelligently requires a thorough understanding of the intended population.

Sutcliffe (1988) adds that the interface design should be such that it offers guidance not control. That is the design should guide the user through a task with prompts and gives feedback information. The interface should function at the user's pace according to the user's command and should not attempt to control the user. This principle has two sub-components: predictability – users should be able to forecast what to do next from a system's current state; and reversibility – users should be able to back track at will when mistakes are made.

Generally, people prefer to feel a sense of mastery and control of any tool at their disposal, and the computer is no exception. It is frustrating and demoralizing to feel that you are being controlled and directed by a machine or software. With autonomy, users will soon gain a sense of mastery if the interface is simple, predictable, and consistent.

Sutcliffe (1988) has discussed other principles that are important in the design of educational software as described below.

Compatibility – between the user's expectation and the reality of an interface design should be enhanced. This principle follows on from consistency to state that new designs should be compatible with, and therefore based upon, the user's previous experience. If this is

followed, once again recognition is enhanced, the time taken to learn how to use the system is reduced and the interface is easier to use. The essential compatibility is between the user's mental model of the task and the task model embedded in the software by the designer.

Adaptability – educational interfaces should adapt to the user in several ways. That is the interface should adapt to the user's speed of work and should not enforce continuous attention. Also the interface should adapt to individual user characteristics, skill levels among other things, as to do otherwise would offend the compatibility principle. Adaptability however must not be overdone otherwise the consistency of the interface is reduced. A system may be effective but unpleasant to use or satisfying but ineffective. A satisfying system gives the users the feeling that they are in control.

Economy – interface designs should be economical in the sense that they achieve an operation in the minimum number of steps necessary to support the user and lessen the work of users whenever possible.

2.5.9 Implications of HCI design principles on design and evaluation of OLS

From the above discussion on HCI design principles, it is clear that the design process of effective software should encompass the HCI principles discussed above and educational systems are no exception. Therefore, efforts will be made to establish, investigate and determine whether the HCI principles were observed in the OLS design process.

2.6 Designing-by-constructivism: A reference model for evaluating OLS

In this section *'Designing-by-Constructivism'* model is introduced to describe the process that will be adopted in evaluating OLS. This model is built from the components that were discussed in Section 2.2 to 2.4. The relationships of literature from the previous Sections (2.2 to 2.4) with the model are first repeated in this section. Subsequently, these

relationships are further clarified. *'Designing-by-Constructivism'* model is presented in Figure 12.

User Centred Design
(Pedagogical issues)

Models of Rich Environment for Active Learning (REAL)

(CMC tools to facilitate learning)

(Authentic learning context)

Constructivism
(Social perspective)

Teachers' identities - course facilitating, guiding, scaffolding

HCI Design principles
(Readability, navigation and consistency etc)
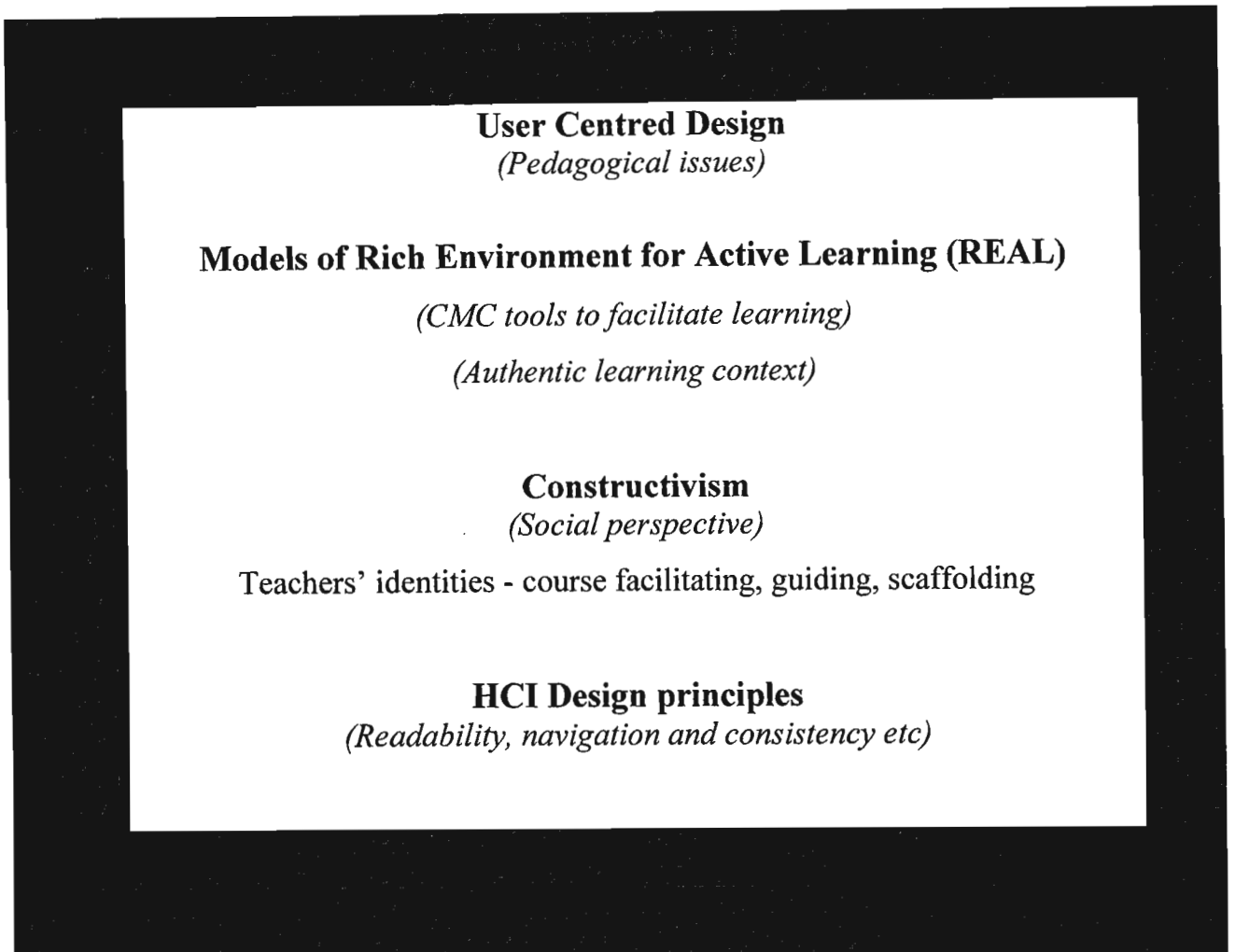
Figure 12: Designing-by-Constructivism model

'Designing-by-Constructivism' model attempts to describe a learning interface of an integrated evaluation process. The model mainly describes a process of social interactions, as stated in Vygotsky's work (see Chapter 2). The reason for focusing on the social constructivism strand is because it is centred on social perspective to learning rather than individualist perspective. The model further builds on aspects of REAL environments (see Chapter 2 Section 2.2.3), the UCD approach (see Chapter 2 Section 2.3) and HCI

principles (see Chapter 2 Section 2.4) - the theme of evaluating the resource. As a reference model for evaluating OLS, one of its aims is to determine whether the resource is grounded on the constructivism epistemology. The CMC tools, which are important in facilitating learning, are emphasized in this model.

The main parts of the model are identified as follows:

Based on Vygotsky's perspective (Section 2.22) the social aspects of learning as described by the social constructivism strand have become useful for those looking to design educational projects. *'Designing-by-Constructivism'* is observed as an implementation of the social constructivist perspective, as many of the aspects of social aspects of learning are present in this model. One of the basic assumptions of Vygotsky's framework is the creation of a social learning environment (Fosnot, 1996). Therefore, designing a learning environment with a combination of different CMC tools is desirable. Schrum (1996) points out that a virtual learning community involves learners who are separated physically and rely completely on communication technology, partially overcoming geographical barriers. Therefore, the social aspects are indicated as part of the constructivism epistemology in all aspects of the *'Designing-by-Constructivism'* model.

Rich Environments for Active Learning (REAL), include a need for learning environments characterised by five themes: student responsibility and initiative, generative learning strategies, authentic learning contexts, authentic assessment and co-operative support (Jonassen, Mayes and McAleese, 1993). In the discussion of REAL, environments that allow for collaboration and those that allow for authentic activities are considered (see Section 2.2.3). Relating the *'Designing-by-Constructivism'* model to REAL is very important as these environments have attributes that make them an excellent choice for the acquisition of transferable knowledge.

Ease of use is vital to the success of most products. This requires focusing on the product's potential users from the very beginning, and checking at each step of the way with these users to be sure they will like and be comfortable with the final design. Therefore, integrating the UCD approach into *'Designing-by-Constructivism'* model is very important as it will help determine if OLS is designed around the users' needs or not.

Similarly, incorporating the HCI design principles into this reference model will help determine if OLS *"human-centred design is characterised by: the active involvement of users and a clear understanding of user and task requirements; an appropriate allocation of function between users and technology; the iteration of design solutions and multi-disciplinary design"* (ISO 13407, 2003).

This model will provide with a framework for iterative evaluation of OLS in the process of creating a learner centred product. This will be possible through conducting a user centred study after which the resource will be revised and a new cycle follows. This on going evaluation is based on users' needs, followed by changes and improvements after which a new evaluation is undertaken. When ongoing reports are received, reflection can take place that can lead to improvements and revisions on the mentioned areas. A continuous (iterative) evaluation is desirable at different stages of the life cycle of the system.

In order to help in the application of *'Designing-by-Constructivism'*, different aspects of the four theoretical frameworks are related to the model. These aspects relate to decisions about the design of the OLS environment in which learning takes place.

Theoretical aspects of *'Designing-by-Constructivism'* with respect to the social constructivist strand

The social constructivist approach used is enabled through the active use of online CMC tools to develop a 'community of learners' (Jonassen, Peck, and Wilson, 1999). Reeves (1993), proposes that design of educational systems should be based upon a strong

foundation of learning theories. He argues that instructivism based designs are sequenced into hierarchies with little emphasis put on the learner per se, who is viewed as a passive recipient of instruction. Alternatively, a constructivist-based approach will assure that the learning environment is as rich and diverse as possible. He further argues that although many developers may deny the influence of behaviourism on their work, it is obvious that behavioural psychology continues to underlie most computer-based education programs. These programs are designed in such a way that they provide stimuli, responses, feedback, reinforcement and other contingencies. Inaccurate responses will result in a repetition of the original stimulus or modified (often simpler) version of it, and the cycle begins again. Cognitive psychology on the other hand, has captured the attention of many educational software designers. In this case the design will support the use of simple propositions, schema, and mental models among other contingencies.

Theoretical aspects of *'Designing-by-Constructivism'* with respect to Rich environment for active learning (REAL)

While evaluating OLS, a focus on different REAL environments is vital for determining whether the product allows for collaboration and the use of authentic activities in learning. In the process of evaluating OLS the three aspects of REAL as already discussed will be explored and their implications and related emerging themes discussed as far as the design of OLS is concerned. Because the themes overlap and reinforce each other, one element can be related to more than one theme, and discussed under the most appropriate theme.

Theoretical aspects of *'Designing-by-Constructivism'* with respect to the UCD approach

Similarly, evaluating OLS with the UCD approach in mind will help to determine if the product is designer-centred or user-centred. This can be determined through defining usability goals and objectives; identifying user needs, characteristics, expectations, capabilities, and limitations; performing task analysis; applying proven HCI factors to the design; evaluating design consistency, flexibility, and functionality; evaluating design

alternatives; determining the importance of design of online help, documentation and computer-based training. Last but not least executing usability tests and observatory evaluations so as to establish benchmarks and enhance overall designs are also important (The Human Factor Inc, 2002).

Theoretical aspects of *'Designing-by-Constructivism'* with respect to the HCI principles

Bearing in mind that HCI is the process of designing interface software so that computer systems are efficient, pleasant, and easy to use and do what people want them to (Sutcliffe, 1988), the principles that were discussed in Chapter 2 Section 2.4 are incorporated into the *'Designing-by-Constructivism'* model. As earlier noted, these principles are: anticipation, autonomy, graphic design and colour, consistency, language, efficiency of the user, navigation interfaces, adaptability, presentation learn-ability, metaphor use, flexibility, readability, errors, memory load, accessibility, protection of users' work and visible navigation.

Providing a model for evaluation of educational software design is very important as design guidelines give an overview of the most important aspect of designing and gives directions for action. More design guidelines have been discussed under the UCD and HCI approach in Chapter 2 Section 2.3 and 2.4.

'Designing-by-Constructivism' **model**

Therefore, we can view a learning system as a vehicle of transmission between the course facilitator and the learners. This framework is grounded on the constructivism approach and REAL environment and guided by the UCD and HCI design principles. In this framework teachers are no longer viewed as instructors and their role is not 'teacher telling' but rather their role in the learning process is to scaffold, facilitate and guide the learner in the construction of ideas. Pressley and Hogan (1996) define scaffolding as the

process of providing assistance to students on an as-needed basis with the fading of assistance as their competence increases.

One major advantage of developing the *'Designing-by-Constructivism'* model is that it facilitates to answer the research questions in the literature review through analysis of specific aspects of OLS. This model will also play a very important role in integrating these different approaches, principles and pedagogies.

2. 7 Conclusion

In deed it is possible to design learning systems around the user needs, thereby improving the human computer interaction and at the same time providing a learning environment where the learners are able to construct and share ideas. With the growing number of student centred studies being conducted that are designed to teach how the appropriate use of technology and pedagogy could make online learning more beneficial for learning institutions and with more significant research dealing with variables that affect education being done, it is apparent that research will also contribute in the field of online learning and also prompt online educators and researchers to ask further questions that relate to technological effects on education and how these environments enhance cognitive activities. Similarly this will result with more appropriate educational design reference frameworks/models.

From the literature review five interrelated aspects of human-computer interaction seems to emerge. These are the nature of *human-computer interaction* (HCI principles), the *use and context of computers* (application areas and social organization), the *human characteristics* (language, communication, interaction and information processing), *computer system and interface architecture* (graphics, dialogue techniques and genre), and the *development process* (design approaches, implementation techniques and evaluation techniques).

Likewise, it is notable that the UCD educational software can provide a bridge between a learner's existing knowledge, skills and the demands of a task, by providing a structure and a link between the known and the unknown and also support the learners' problem solving. UCD can provide the representational tools to model or simulate an 'out of reach' concept, thus creating an authentic environment for the learner. It can also provide the novice with an environment to undertake a task at his/her existing level of competency.

The use of technology such as online learning, in learning will not, as some fear, mean the demise of face-to-face learning, as we know it; rather, technology will reorganize what we believe about learning and the relationships between students, teacher, information and facilities will improve. Successful online learning programs rely on consistent and integrated efforts of students, faculty, facilitators, support staff, and administrators. Nevertheless, notable success is based upon a mutual relationship between students and course facilitator. Similarly, Students will still have to take a greater degree of responsibility for their own learning, and facilitators will need to consider the ways they can support, guide, facilitate, and manage effective online learning.

All the issues above are important in using technology to improve student achievement. Educational technology is not, and will never be transformative on its own. But when decisions are made strategically with these issues in mind, technology can play a critical role in creating new circumstances and opportunities for learning that can be rich and exciting. At its best, technology can facilitate deep exploration and integration of information, high-level thinking, and profound engagement by allowing students to design, explore, experiment, access information, and model complex phenomena. These new circumstances and opportunities, not the technology by its own can have a direct and meaningful impact on student achievement.

CHAPTER 3

RESEARCH METHODOLOGY AND METHODS

3.1 Introduction

In Chapter 2 four theoretical aspects for evaluating OLS were identified. These aspects were integrated to form a reference model of design evaluation called *'Designing-by-Constructivism'*. While in the previous chapter this model was conceptualised from a theoretical viewpoint, in this chapter a practical methodological approach will be explored and discussed. This research approach forms a link between the literature review and results and discussions.

In an attempt to address the main theoretical and practical research questions of this study, a mixed methodology (triangulation) approach was adopted. That is the use of qualitative and quantitative techniques. Although these techniques are derived from divergent theoretical approaches, there is nothing inherent in the methods themselves that prohibits their combination. In fact, respected research practitioners such as Jones (1997) and Nau (1995) have supported integrating the two approaches building on their complementary strengths.

Others have stressed the advantage of linking qualitative and quantitative methods when performing studies and evaluations, showing how the validity and usefulness of findings could benefit research (White, 2000). Qualitative data can support and explicate the meaning of quantitative research. Nielsen (1993) recommends that a combination of usability methods is often useful. This is because different usability categories can show fairly distinct sets of usability problems, meaning that they supplement each other rather than leading to repetitive findings. In a quantitative evaluation, the purpose is to come up with some objective metric of human performance that can be used to compare interacting phenomena. This can be contrasted with a qualitative evaluation, in which the purpose is to derive deeper understanding of the human interaction experience (Dix *et al.*, 1993).

The use of triangulation in this research study is because each of the data collection techniques taps different dimension of the problems and issues under investigations.

Hilton (2002) in an online paper writes;

"Triangulating is used to provide confirmation and completeness. It is not the simple combination of different kinds of data but the attempt to relate them so as to counteract the threats of validity in each. Using triangulation can capture a more complete, holistic and contextual portrayal and reveal the varied dimensions of the given phenomenon. It should not be expected that each source of data would confirm each other. Rather, each source will contribute an additional piece to the puzzle and in that way complement each other. The researcher's bias can be minimised and the validity of the findings enhanced. Neither qualitative nor quantitative methods can fully deliver on the promise to establish the truth, however combined judiciously the combination of methods can provide more complete insight. Using several methods also helps to rule out rival explanations."

The data was collected through a combination of instruments namely: a questionnaire (Section 3.2), an evaluation matrix (3.3) and an interview (Section 3.4). These were conducted after some weeks of the participants using the system, so as to allow the participants to become familiar with the resource. A section called bugs and suggestions that had been set in the resource also served as a source of data that related to the problems and bugs that the users encountered.

Pilot study

Two course facilitators (module creators) and five learners (module consumers) participated in the quantitative and qualitative pilot study. The questionnaire, the evaluation matrix and the interviews were administered in the pilot study and the data was analysed. This assisted in the presentation of a paper for the 5th WWW Applications conference at the University of Durban Westville, South Africa in 2003. The pilot study

allowed for making minor adjustments and clarifications to some of the questions. It is worth noting that since only minor changes were made to the questionnaire and the interview sheet, the data from the pilot study was incorporated in the final analysis.

3.2 Questionnaire

One of the instruments used in the study was a questionnaire. This supplemented the interviews and increased a further understanding about particular issues such as the users' view on the resource. The questionnaire being a quantitative research technique allows flexibility in the treatment of data, in terms of comparative analysis, statistical analysis and repeatability of data collection in order to verify reliability. That is, questionnaire allows comparison and replication as well as reliability and validity to be determined more objectively (Jones, 1997).

Five staff members and 38 learners responded to the questionnaire, 30 of these learners were second year undergraduate biology students who were undertaking a course called 'Protein, structure and function'. These Biology students were studying under a mixed approach, which included face-to-face learning in conjunction with online learning. However one of the questionnaires was excluded in the analysis, as the responses given were vague. The other learners were honours and masters students in Digital Media who were undertaking four modules, which were purely online. Each of these modules took a period of two weeks.

3.2.1 Questionnaire construction process

A questionnaire was constructed with similar instruments developed by Tuckman (1979) and it was divided into four sections (see Appendix 2). Each question consisted of a statement followed by a choice of four possible answers. All the 34 questions were answered on a four -point Likert scale, with the score of 1 and 2 being negative (disagreed) and 2 and 4 being positive (agreed).

The first three sections were in a tabular format where the users' circled the answer that most appropriately reflected their impression about OLS. Section 1 was designed to probe the users' reflections and feelings on the design, Section 2 investigated their perception on the elements and design characteristics, and Section 3 probed the users' views on the learning resource tools. Three of these tools were Computer-Mediated Communication (CMC) tools (that is e-mail, chat and discussion forum), the other one was a navigation element called My Modules, which is used for accessing the users modules/courses, the other tools were the Calendar, appointment and tasks, icons and customisation themes tools. Section 4 required the participants to fill in the answer that they found most appropriate from among the four choices that were provided to complete a statement. The aim of this section was to find out the users' overall perception of the OLS design. Lastly a section to fill in comments and suggestions was provided. SPSS software was used to determine the percentages frequency of the data. SPSS provides access to a wide range of statistical analysis and data management procedures. The level of frequencies was then compared with the results obtained from the interviews.

3.3 Evaluation Matrix

In addition, an evaluation matrix was attached at the end of the questionnaire, whereby the participants rated the resource. The evaluation matrix required the users to rate the effectiveness and the design features of the resource. These were: colour, metaphor, language, information presentation, user control, graphical user interface and visual consistency. This was tabulated into two columns with one column containing the evaluation item and the other column was set aside for the rating scale. Where: 4 implied the element was excellent, 3 - good, 2 - fair and 1 - poor.

3.4 Interviews

In order to fully evaluate OLS, it was felt that the users' perceptions and views of the resource should also be assessed using an interview. This form of research utilizes qualitative methodology since the intention is to obtain an authentic understanding of interviewees' individual perceptions and attitudes towards the resource.

Interview, a qualitative method, tends to focus on meaning not gleaned through statistical procedure rigorously measured by such tools as questionnaires. They rather base their exploration on observation and open interviews that enable them to discover not only patterns of behaviours but also the subjective meaning the participants give (Strauss and Corbin, 1990).

Although conducting the interviews is more difficult, more stressful and time consuming than most of the other research methods, Shneiderman (1987) suggests that they are important as they provide direct information, are naturalistic and give a 'feel' of users' attitude towards the system. They are also productive and lead to constructive suggestions because the researcher is able to pursue specific issues of concern.

In qualitative research four methods are employed, which are observation, text and documents analysis, interviews and recording. These methods are often combined, for example, in the course of this research a mix of interviews and recording were simultaneously applied. During the interviews, in addition to taking notes, a tape recorder was used to record the discussion verbatim in order to avoid missing any important points. The interviews were transcribed immediately and comparisons made with the notes taken – again to avoid omitting important information.

Face-to-face in-depth interviews using open-ended, non-leading questions were used (see Appendix 2). This type of interview is suitable for this study, which deals with users' perceptions. White (2000) notes that semi structured and unstructured interviews are excellent where the aim of the study is to understand the perspective of the interviewee and the personal meanings they attach to different situations. A semi-structured interview also allows the respondents to express themselves in their own terms with minimum control over the informant's responses being exercised by the researcher. The users were selected to participate in the interviews on informed consent. They were encouraged to participate by suggesting that the dissertation would be made available to them and by giving them the feeling that their suggestions would help improve the overall resource.

Users were asked to describe their relevant activities. 'Why' questions were asked to get at the major goals. 'How' questions were asked to get to the details of actions in accomplishing their goals. Users' workflow patterns, users' conceptual frameworks, and the interrelationships between user objects and tasks were also derived from the interviews (Mayhew, 1992). The unstructured questions allowed the interviewees to answer the questions in detail. In a few instances, semi- structured questions requiring a 'Yes' or 'No' answer were used. These were intended to confirm certain facts and were followed by probing questions for interviewees to make clarifications.

The interviews[2] were conducted after the users familiarized themselves with the system. This was aimed at allowing the users to actually construct their own social world of the resource. In qualitative research this method is referred to as 'interactionism'; its primary aim is to generate information, which gives authentic insight into peoples experiences through unstructured and semi-structured interviews (Silverman, 1993). Nevertheless, this approach has a weakness in that the open-ended interviewing approach in itself is a form of social control, which shapes what people say. Some interviewees talked at length to expand on their views and sometimes I felt compelled to move on to the next questions.

A total of 20 users participated in the interviews, that is 4 course facilitators (module creators) and 16 learners (module consumers). These participants were chosen on volunteer basis. Apart from the biology students and their course facilitator, appointments were made with the interviewees and they were interviewed individually. These interviews were conducted at different venues, at the convenience of each participant. As for the biology group an appointment was scheduled with their course facilitator via e-mail and individual interviews were conducted in one of the laboratory offices where the students were doing their biology practical.

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[2] The interviews were conducted from August 2003 and October 2003. The data collection process was conducted at different times as the users were from different departments in the University of Natal and were using the system at different periods

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The interviews begun with making the interviewee feel comfortable and relaxed. This commenced with thanking the interviewee followed by a brief discussion of what the study entailed, its background and relevance. The nature and format of the interview was also explained and permission was sought from the interviewee to record the interview. A confirmation to the individual interviewees that their responses would be confidential and their names would not appear on the final report was done.

The data collected from the interview was analysed using interpretive methodology, a qualitative approach, which was aided by NVivo; computer based qualitative analysis software. The main reason for the choice of interpretive methodology was because the data collected was descriptive in nature. During the interpretation, meaning on the analysed data was given and compared with those advanced by the literature reviews. However, the weakness of this method of data analysis is that it could be subject to researcher bias in the interpretation of the data.

3.5 Triangulation

The data analysis phase for both the qualitative and quantitative techniques were done through analysis triangulation. This is because more than one strategy was used to analyse the same data. This encompassed four stages: data overview, reduction, description and classification. The parameters used included; association - looking for patterns where one event is connected to another event; sequence or path analysis - looking for patterns where one event leads to another later event; classification - looking for new patterns; clustering - finding and visually documenting groups of facts not previously known; forecasting - discovering patterns in data that can lead to reasonable predictions about the future.

The analysis was aided by the use of various strategies, which are: coding and text analysis. Specialist software package for qualitative and quantitative data analysis was used, namely, QSR NVivo (QSR, 2002) and SPSS software respectively. The quantitative data, which was collected using the questionnaire and the evaluation matrix, was recoded so that the variables can be reduced from four to two. That is those who agreed and

strongly agreed were merged into agreed and those who disagreed and strongly disagreed were reduced into disagreed.

The results were obtained through the feedback collected from the qualitative and quantitative data collection methods, focusing on: consistency in the patterns and connections found in the responses from the participants; analysis of the differences/deviations from patterns of thought that exist in their responses and the factors that could explain these responses and interesting information that was not expected but emerged from the responses. This led to discovery of patterns in data that led to reasonable predictions, the problems encountered and the ways the resource could be improved. Errors in research design or data collection that may compromise the evaluation results were noted. Such errors pose threats to the study's reliability and validity. Comparisons were made between the data collected and the interview data during the analysis stage.

Drawing the conclusions involved stepping back to consider what the analysed data meant and to assessing their implications for the questions at hand. Verifications were done by revisiting the data as many times as necessary so as to crosscheck or verify these emergent conclusions. The purpose was to find out whether the conclusions being drawn from the data were credible, defensible, warranted and able to withstand alternative explanations.

3.6 Conclusion

The crucial aspect in justifying a mixed methodology research design is that both single methodology approaches (quantitative only and qualitative only) have strengths and weaknesses. The combination of methodologies, on the other hand, can focus on their relevant strengths. In so doing the study was able to achieve what Nau (1995) views as blending qualitative and quantitative methods of research to produce a final product, which highlights the significant contributions of both.

Both approaches were fruitful, for example it was possible to ask users to recall critical incidents in their use of the system. These were occasional incidents where the system was particularly poor or surprisingly good.

During the interviews, it was possible to continuously evaluate the users' replies, thereby making it possible to rephrase questions that seemed to have been misunderstood. While in the case of the questionnaire, which had to stand on its own, the pilot tests were very helpful.

The rating scale was also a success as it assisted in finding out how well the users liked various aspects of the system or how useful they found different features.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter details the results and discussions. The results are derived from the quantitative and qualitative analysis of the collected data. Selection of the relevant questions has been done and a discussion of the results given. These results and discussion have been described, interpreted and summarized based on the theoretical model that was proposed in Chapter 2, *'Designing-by-Constructivism'* model. This model integrates the HCI principle, the UCD approach, the REAL environment and the constructivism epistemology to form one reference model.

The chapter is divided into three main sections. In section 4.2 results of the quantitative technique namely the questionnaire and the evaluation matrix are discussed, Section 4.3 discusses results of qualitative techniques namely interviews, while Section 4.4 is comprised of further discussions and conclusions in an attempt to further relate the results with the *'Designing-by-Constructivism'* model.

As discussed in the previous chapters' triangulation has been applied in this chapter that is in some instances the qualitative results are used to supplement the quantitative results and vice versa.

4.2 Quantitative results

4.2.1 Questionnaire

The questionnaire was analysed using SPSS; a quantitative analysis software. Quantitative research methodology allows the measurement, comparison and statistical analysis of general characteristics of a population (Jones, 1997). For this reason, it was an appropriate research approach for identifying the most prolific perceptions the users had regarding the OLS.

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The analyses were done for each section. For ease of analysis and interpretation, data reduction was done from the original four - point Likert scale to two-point scale.

There were four main objectives in the questionnaire. The first objective was to find out the users reflections, feelings and attitude towards the OLS system. The second was to investigate their perception on the quality of the resource. The third was to establish the tools and elements that users viewed as important and the fourth was to determine the overall users, perception and attitude towards the system, while the fifth aimed at determining the users' general and overall perceptions towards OLS.

The frequency percentages of some questions were not equals to 100% the reason being that there were instances where there were missing values in the responses. From the analysis the missing values range from 2.4% to 4.8% where 2.4% represents one missing value and 4.8% represents two missing values. This is not a very high value considering that the number of questions under analysis were 42. Therefore these missing values were not significant, hence did not have any significant impact on the study

Section 1: Design of the resource

The purpose of this section was to address the first objective (the users' reflections and feelings about OLS design). These questions revolved around navigation, use of computer terms, language, error messages and human memory limitations.

Table 2: Percentage frequencies of users,' responses to design descriptions

No	DESCRIPTION	Percentages		
		Agreed	Disagreed	Missing values
1	Navigating between the pages was not difficult.	75.6	22	2.4
2	Computer related terms were appropriately used	85.4	12.2	2.4
3	I clearly understood the error messages	58.5	39.1	2.4
4	Using the resource was not difficult	87.8	9.8	2.4
5	It was not difficult to log into the resource	68.3	29.3	2.4
6	Appropriate authentication and security features are present	73.2	24.4	2.4
7	Navigation between different part of the resource is logical	75.6	19.6	4.8
8	The tools used support my learning style	68.3	29.3	2.4
9	Learning new features was not difficult.	75.6	26.0	2.4
10	The human memory limitations were considered	82.9	14.7	2.4
11	The language and format used is well expressed	87.8	9.8	2.4
12	The resource encourages collaboration and interaction	87.8	9.8	2.4

Questions 1 and 7 aimed at identifying the resource design with relation to navigation, one of the most important HCI design element (see Chapter 2 Section 2.43). In these questions, 75% of users' agreed that the navigation principle is easy in OLS design. More insights and reasons of those who disagreed were gained from the qualitative analysis, for example see Section 2 Response 7.

Results for Question 2 and 11 showed that more than 80% of the users found the use of computer terms and language to be appropriate. This shows that OLS designer paid particular attention to language in the system design.

The third question had 58.5% agreeing and 39.1% disagreeing that they clearly understood the error messages they encountered. This indicates that a big percentage of the users did not understand the error messages. Qualitative analysis on Section 1 Question 2 also supports this. Error messages and prevention is another important HCI design principle as discussed in Chapter 2.

Analysis of question 4, 9 and 10 indicates that the users did not have difficulties using OLS (above 80% of the users agreed). The qualitative analysis in Section 1 (Question 1 (a) & (b), and Question 3) and Section 2 (Question 1) gives more clear insights in support of these findings. These results indicate that the UCD approach was applied in the OLS design process and the HCI principles such as memorability, utility and effectiveness were observed.

The percentage frequencies of question 5, which aimed at finding out if the users had any difficulties logging into the system shows that 29% of the respondents, experienced a problem when they tried to log into the system. Useful reasons related to this problem were gained in the qualitative analysis on Section 1 Question 1 (a) and (b).

Analysis of Question 6 indicates that 73.2% of the respondents agreed that appropriate authentication and security features were present in the system. However, 24.4% of users did not agree with this statement. The reason as observed from qualitative results was due to logging in problems, other would like to have a logging off button (this is further discussed in the qualitative analysis).

In Question nine, 68.3% of the respondents agreed that OLS supported their learning style while 29.3% disagreed. Comparatively, the number of those who disagreed is large enough. This Question had a bearing on the Piaget individualistic perspective of whether the individuals are supplied with a learning environment that allow them to learn by being able to discover and reconstruct concepts in a personally meaningful way (see Chapter 2, cognitive constructivism strand). From this result we realize that OLS does not provide a

stable-enough environments for integrating individualistic learning approaches but rather it provides with a rich social perspective.

Question 12 aimed at investigating whether OLS was actually grounded on the constructivism approach with special reference to the social constructivism strand (see Chapter 2 on social constructivism strand). Vygotsky perceived learning to be a social and active process. This can be facilitated through interaction and collaboration. From the analysis 87.8% of the respondents agreed that OLS encouraged collaboration and interaction. This is a relatively high percentage. Indeed the qualitative analysis strongly supported these findings (see Section 2 question 5 and 6).

Section 2: Perceptions of quality

Section two aimed to address the second objective that investigated users' perceptions on the elements and design characteristics of the resource.

Table 3: Percentage frequency scores of users' responses to statements regarding their perceptions of the resource quality.

No.	Consistency of the following characteristics	Percentages		
		Agreed	Disagreed	Missing Values
13	The use of colour	80.5	14.7	4.8
14	Sequence of displays	90.3	7.3	2.4
15	Terminology use	95.2	2.4	2.4
16	Character contrast with background	78.0	19.6	2.4
17	The graphics used	80.5	17.1	2.4
18	The links and navigation	82.9	14.7	2.4
19	The interface design	78.0	19.6	2.4

As in Table 1 the missing values here are relatively insignificant. The four-point Likert scale used varied from low consistency to high consistency. Consistency is another very

important HCI design principle (see Chapter Section 2.44) and UCD aspect (see Chapter 2 Section 2.3) as it reduces the human learning load and increases recognition by presenting a familiar pattern. In this case consistency of OLS was analysed with special reference to colour and sequence of display, use of terminology, contrast, which affects readability, graphics, navigation and overall design with regard to UCD and HCI principles.

From the Table, 80.5% of the respondents agreed that the use of colour was consistent throughout the resource (Question 13). The reasons for 14.3% of those who disagreed can be accounted for in the qualitative analysis where the users expressed the need to have more colour options under customisation themes.

On the issue of sequence of display (Question 14), 90.3% of the respondents agreed that the consistency principle was applied in the OLS design. This is a high percentage, which indicates that the displays of different OLS pages are consistent.

The use of terminology (Question 15) also proves to be consistent with a very positive response rate of 95.2%. This corroborates the earlier findings that were observed in Table 2, Question 2 and 4 (i.e. computer related terms were appropriately used and using the resource was not difficult).

Consistency of OLS with regard to character contrast with background (Question 16) similarly shows that a high percentage of the respondents agreed that consistency was adhered to (these are 78.0%). We can account for the 19.6% of those who disagreed with the same reason as for colour element as these two elements are highly related.

Regarding Question 17, most of the respondents (80.5%) agreed that the use of graphic in OLS was consistent. This too is a high percentage. The appropriate use of graphics and graphic symbolism is very important in a learning resource as these two elements have a bearing on the users' interpretation of concepts (see page 51). Again we can apply the

mixed methodology approach to give explanations for 17.1% who disagreed on this statement (see Section 2 Question 4 qualitative results).

From the analysis of Question 18, we observe that 82.9% of the respondents agreed that the links and navigation within OLS were consistent. This also serves to explain Questions 1 and 7.

Last but not least on consistency was Question 19, whose analysis points towards a high users' satisfaction with the interface design, where 78.0% of the respondents agreed to the effect that the OLS design was consistent, offered flexibility and functionality. Yet again, we can apply the mixed methodology approach to explain about the 19.4% who disagreed to this statement (see Section 2 Question 3 and 4 qualitative results).

From the above result and discussion with regard to consistency, it seems that design of OLS is built on a consistent pattern of modular units that share the same basic layout grids, graphic themes, editorial conventions and hierarchies of organization (see figure 12 below). This has largely been supported by the qualitative results where most of the users expressed that OLS was *"consistent and predictable"* with their *"expectations largely met"*. The graphic identity of the pages within OLS provides the users with the visual cues to the continuity of information. The header menu graphics present on every page of OLS creates a consistent user interface thereby creating a 'seamless' system of pages:
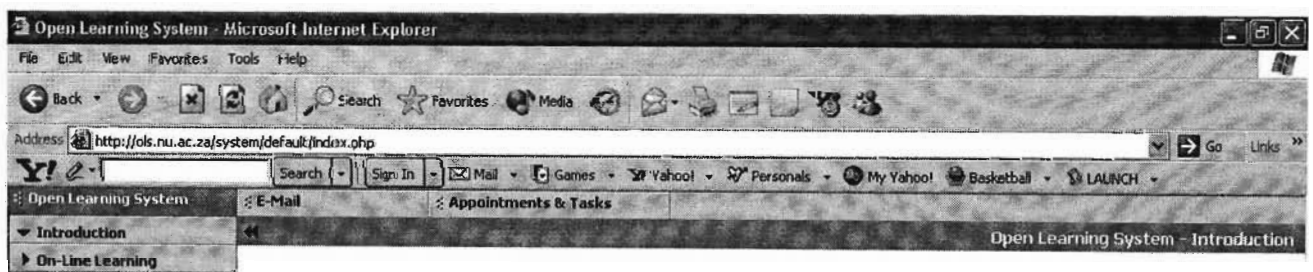
Figure 13: Consistent header menu of OLS

Section 3: The learning resource attributes and elements

The purpose of this Section was to address the third objective (the tools and elements that users found to be important). In this section there were no missing values, implying that the users understood the questions under investigation.

Table 4: Percentage frequency scores of users' responses to statements regarding the learning resource attributes and elements

No.	ELEMENT	Percentage	
		Agreed	Disagreed
20	Email	78.6	21.4
21	Appointments & Tasks	65.8	34.2
22	Calendar	61.9	38.1
23	My Modules	97.6	2.4
24	Discussion forum	90.2	9.8
25	Chat	71.4	28.6
26	Icons	76.2	23.8
27	Customisation themes	78.6	21.2

The results in Table 4 indicate the users' appreciation and acceptance of the tools and elements in OLS. However, as observed the percentages vary greatly.

The first tool under investigation was e-mail, an asynchronous CMC tool (see page 33), where 75.6% of the respondents agreed and 21.4% disagreed that e-mail is an important CMC tool. This is a relatively high positive response rate; nevertheless the number of those who disagreed is relatively high and valid. Again the reason for this response is highlighted in the qualitative analysis results where some of the users indicated that they had not fully utilized the resource.

Question 21 and 22 shared almost equal responses, having around 60% agreeing and around 30% disagreeing that the Appointments & Tasks and the Calendar are important

tools in OLS. We cannot adequately refute that these two elements are unimportant in the resource, as any percentage above 50% is acceptable. From the qualitative analysis the users who disagreed gave the same reason as in the case of e-mail while others suggested that they did not find these two tools to be important in their learning situation.

For Question 23, most of the respondents found My Module, the navigation element for accessing modules and courses to be important (95.1%). This is a very high percentage and the reason that can be given for this is that My Module is one the most central element in learning.

On the level of importance 'My Module' was followed by the discussion forum, another asynchronous CMC tool (see page 34), of which 90.2% of the respondents agreed that the discussion forum is an important tool. This was supported by several qualitative responses, which indicated that the discussion forum was important as it allowed for collaboration learning, a strong social constructivism theme. With regard to the analysis of Question 25, the results indicate that 71.4% of the respondents agreed that the chat, a synchronous CMC tool was important while 28.6% viewed the tool as unimportant. On the contrary, the qualitative analysis indicates a higher number of users' appreciated the chat tool. From the qualitative analysis results, some users indicated that they had not fully utilized the resource.

Questions 26 and 27 gained the same percentage of responses. These elements are icons and customization themes, where 78.0% of the respondents agreed and 19.5% disagreed on the importance of these elements. Once more, 78.0% is a high response rate, nevertheless supplementing from the qualitative analysis we observe that some users expressed the desire to have more customization abilities and use icons that are relevant and related in their learning environments (see Section 2 Question 4 and Table 9 qualitative results).

Section 4: The overall design

Section two aimed at addressing the fourth objective (users' general and overall perceptions towards OLS).

Table 5: Percentage frequency scores of users' responses to statements regarding the overall OLS design

No.	OVERALL DESIGN	Percentages		
		Agreed	Disagreed	Missing values
28	Learning the operations	85.7	14.3	0
29	Human memory limitations	85.7	14.3	0
30	Use by different levels of experience	78.6	21.4	0
31	Metaphor use	61.0	36.6	2.4
32	Overall displays	57.1	40.5	2.4
33	Exploration of features	81.0	16.7	2.4
34	The overall resource	85.7	14.3	0
35	The overall reactions	80.5	20.5	0

Basically the eight questions (Table 5) aimed to confirm and supplement the findings of the three previous Sections. Only three of the eight questions had missing values whose percentage was 2.4 (this indicates only 1 missing value). Question 28, 29 and 30 aimed at finding out whether OLS was user centre designed or designer centred, by probing whether the designer had the users in mind or not. Question 28 and 29 received the same percentage of response. That is 85.7% for those who agreed and 14.3% for those who disagreed. On question thirty, 78.6% of the respondents agreed that OLS was not difficult to use whereas 21.4% disagreed. Generally speaking the positive responses in these three questions are high. However attempts were made to find out the reasons for those who disagreed while undertaking the qualitative interviews. The qualitative analysis results indicated that some users felt that a help manual would serve to alleviate the problems that they encountered.

Questions 31, aimed at investigating the users perception of the overall OLS metaphor. Metaphor is another HCI design principle (see page 55). We use metaphors when we want to convey an abstract concept in a more familiar and accessible form. They are used in interfaces for objects on the screen, types of user interaction and the way the system responds. From the quantitative analysis 61.0% of the respondents agreed that the metaphor was appropriate while 36.6% disagreed. From the qualitative analysis it emerged that those users who disagreed did not understand or perceive the metaphor used, while others were not accustomed to this kind of learning concept, hence the need for online documentation.

Questions 32, 33, 34 and 35 aimed at establishing the users' overall perceptions of OLS with regard to overall displays, resources, reactions and exploration features. These were very important questions, as the design of the resource determines its organizational framework. Apart from the overall display, the other questions received a high rating of over 80%. The overall display received a positive response of 57.1%, which is generally low. More clarity and reasons for this were gained from the interviews.

4.2.2 The evaluation matrix

In addition an evaluation matrix was attached to the questionnaire to help determine the overall perceptions and attitude of the users with regard to design characteristics/elements in the system. These elements have been mentioned in Sections 3 however; this was with regard to consistency, whereas in this evaluation matrix these elements are being evaluated as stand-alones (a 2.4% value indicates 1 missing value).

While the overall perception of the users towards the system was very positive, some evaluation items received lower frequencies than others (that is received a rating of excellent while others received a rating of being fair (see Figure 14 to 20).

Colour and language elements received a high excellent rating of 75.6% and 80.5% respectively (See Figure 14 and 15 respectively). This is a high rating, which confirmed the earlier findings on these two HCI elements.

Pecentages of the participants perception on colour
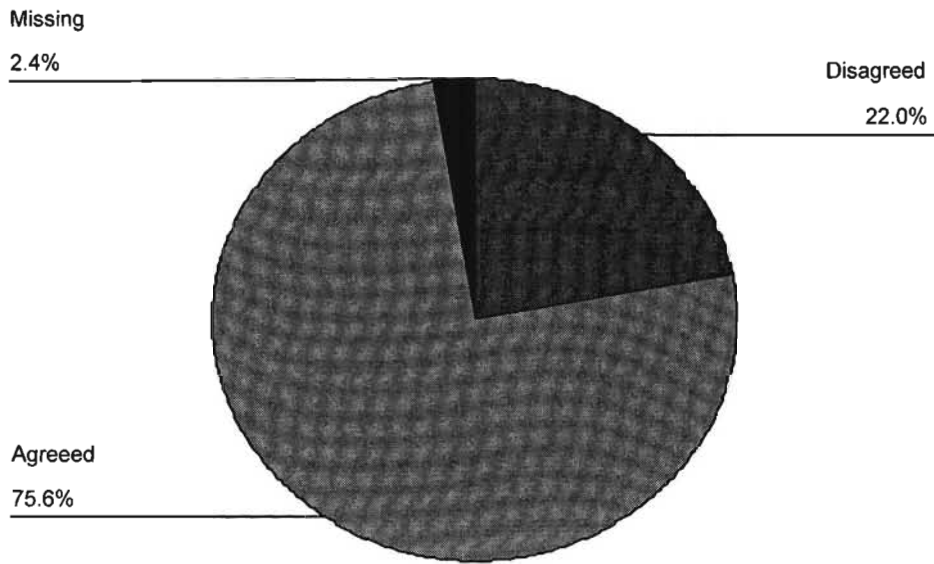
Figure 14: Participants perception on use of color.

Participants perception on language use
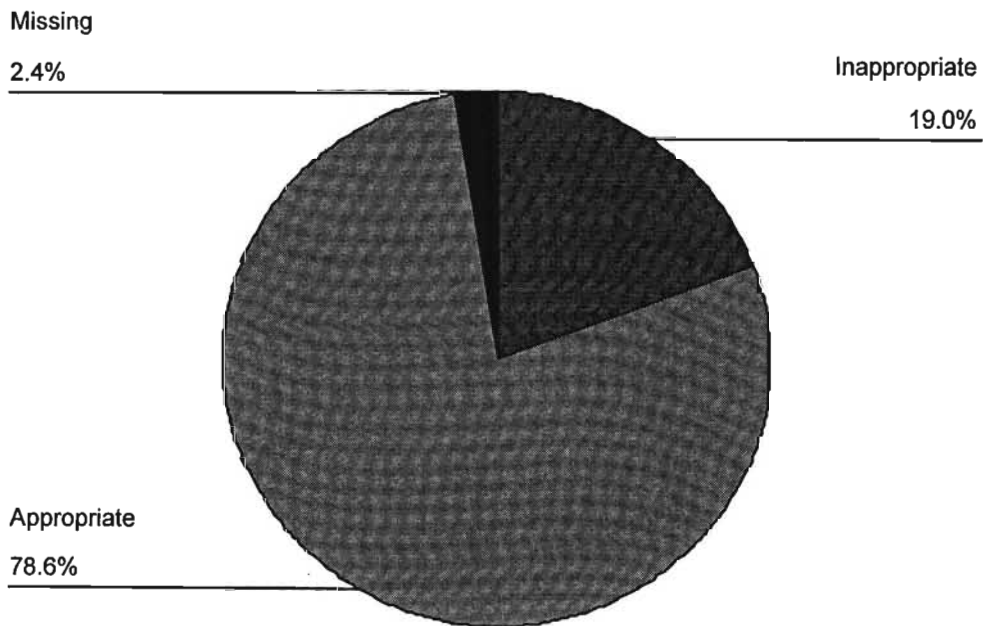
Figure 15: Participants perception on the language use.

On information presentation, 78.6 % of respondents agreed that consistency was observed throughout the OLS (Figure 16). Information presentation is a very important attribute in a learning resource. The reason being that the way information is presented affects readability among other things. Examples of good presentation characteristics include: page layout, typography and colour schemes (see page 44 on readability). This result shows that the information presentation in OLS is consistent and appropriate.

Participants perception on Information presentation
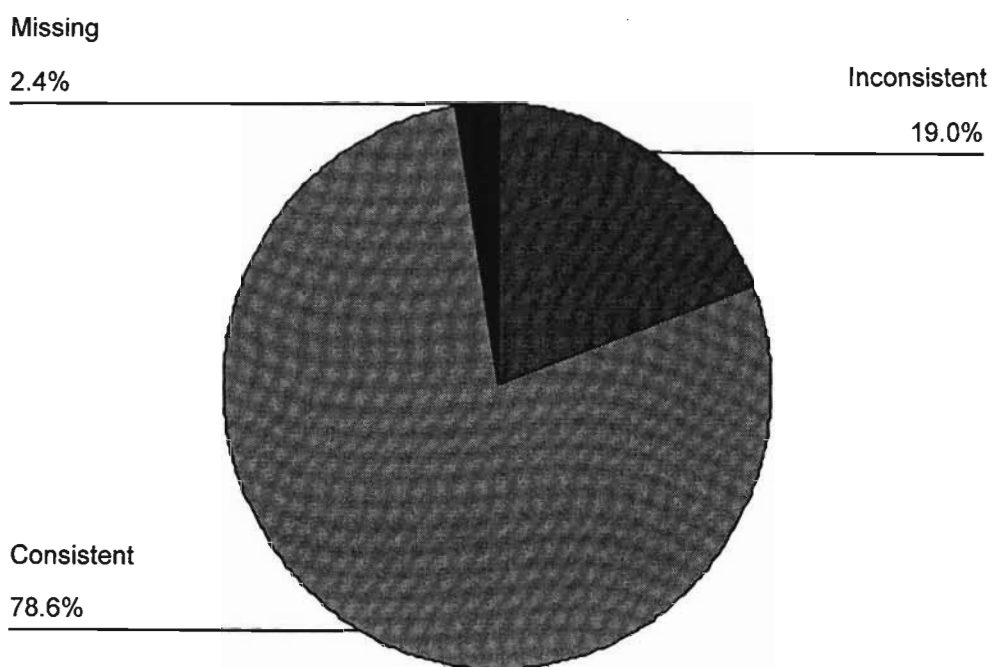
Figure 16: Participants perception on information presentation.

With regard to visual consistency (Figure 17), 83.3 % of respondents agreed that visual consistency was observed in OLS design structure. This also supports earlier findings with regard to use of color and graphics.

Participants perception on visual consistentcy
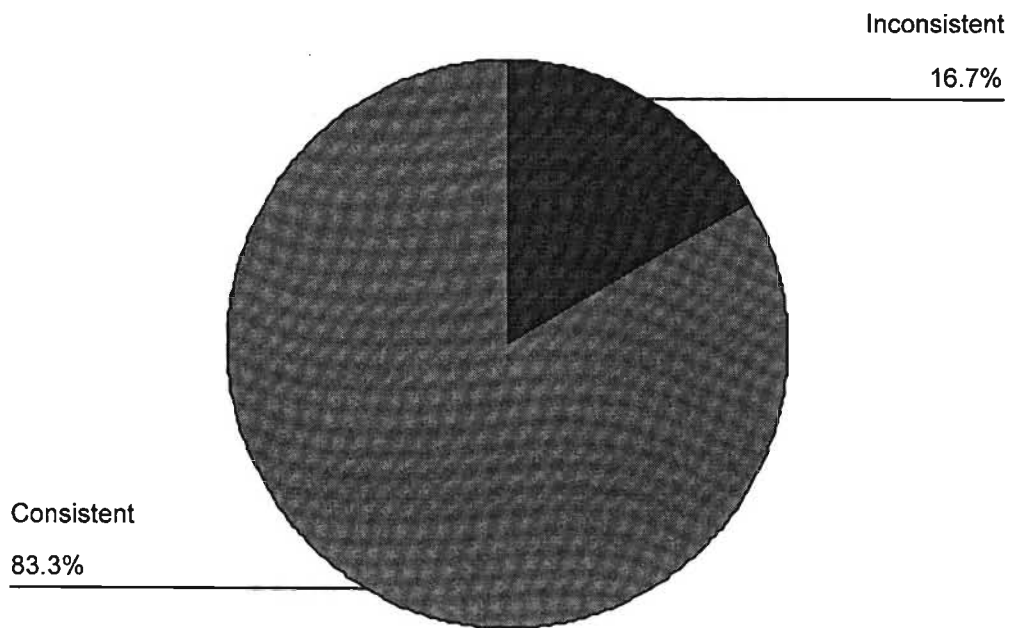
Figure 17: Participants perception on visual consistency.

The use of metaphor (Figure 18) did not receive a high positive response (most users' rated this aspect as fair); with 52.3% of respondents agreeing that metaphor use was appropriate while 47.7% disagreeing. However, it is not known if users understood the application of metaphor in this context.

Participants perception on the use of metaphor
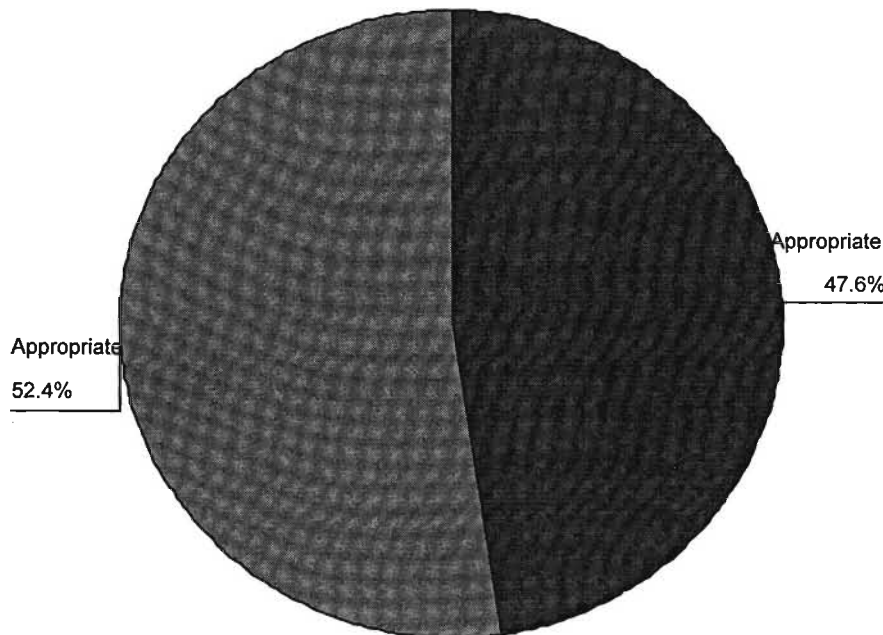
Figure 18: Participants perception on the use of metaphor

Similarly, user control element (Figure 19) did not receive a high positive response, with 57.1% of the respondents agreeing that user control was available and 42.9% disagreeing. More insights on this were gained during the qualitative results analysis where for example some users expressed the desire to be able to use their own icons and to have more control over the peer review tool such as reviewing articles off-line and saving articles on disk.

Participants perception on users control
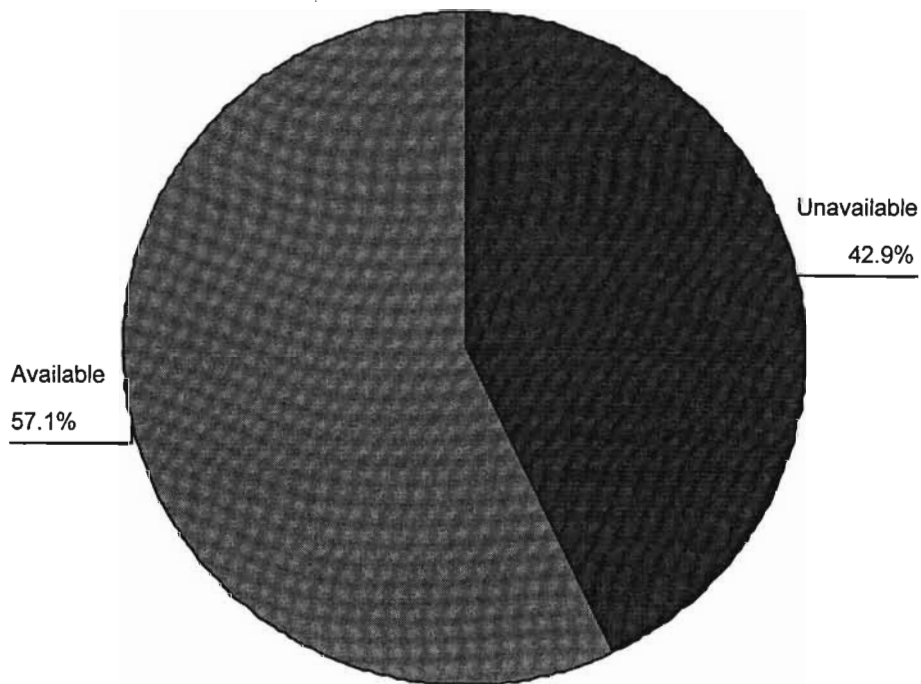
Figure 19: Participants perception on autonomy

The Graphical User Interface (GUI) (Figure 20) also did not receive a high percentage of response, with 53.7% agreeing that the GUI used were appropriate with 43.9% disagreeing. Reasons to supplement these results were derived from the qualitative analysis and they were related to user control element. There is also a probability that the users did not fully understand the concept of GUI.

Participants perception on Graphical User Interface (GUI)
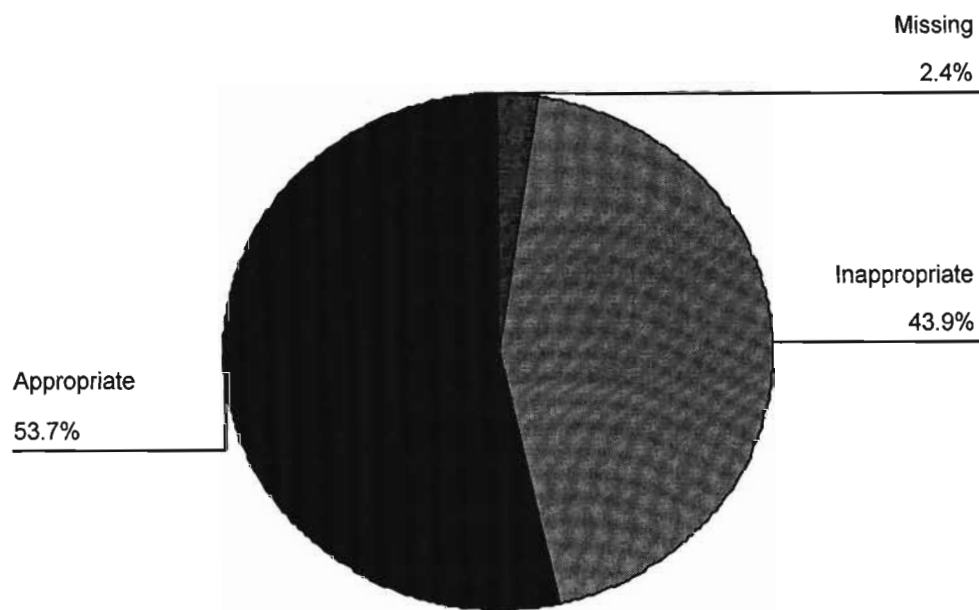
Figure 20: Participants perception on the use of Graphical User Interfaces.

Section 5: Additional comments and suggestions

In this part of the questionnaire not all users gave suggestions and comment. However, there are some few users who did give some suggestions; *"The system is okay, user friendly it just needs some fancy color to attract the users"*; *"lecture notes have to be copied and pasted onto word not very good"*; *"please enlarge font size"* *"more lecturers should consider using OLS. It is very user friendly and easy to use"*

From the results of this quantitative analysis and discussion, it can be concluded that OLS was well received, and the CMC tools, customisation themes and navigation features were highly appreciated.

There are many factors and reasons that can be considered in contributing to the results obtained from the questionnaire analysis. To gain additional insight into such factors and reasons, qualitative research was also conducted using interviews.

4.3 Qualitative results and discussion

4.3.1 Interviews

Interviews were undertaken to identify problems that the users encountered (Section 1); the users' opinions and experiences of the resource (Section 2) and to find out the tools that the users' would like added to the resource (Section 3). Twenty users participated in the interviews.

The extraction of the qualitative results was aided by the use of NVivo, a computer software package for qualitative analysis. The audio recorded interviews were transcribed and the texts were saved in rich text format (RTF) and imported to NVivo for analysis. This facilitated the extraction of interesting themes. The responses were analyzed and discussed as outlined below.

In order to understand the different inter-related, yet distinctive concepts of the users' perceptions and views, an enhanced pictorial framework of *'Designing-by-Constructivism'* model with elements similar to those in Figure 11 was constructed using Nvivo (Figure 21). In pictorial format, the model elicited the directional links of different elements, tools and features and key themes that were under investigation. Different colors and link appearances were used to indicate their strengths and importance. The model further assisted in developing, considering and recording thoughts about different concepts and

their relationships. Construction of the same model in two different formats and stages allowed for further reflections and the issues under investigation became clearer each time.
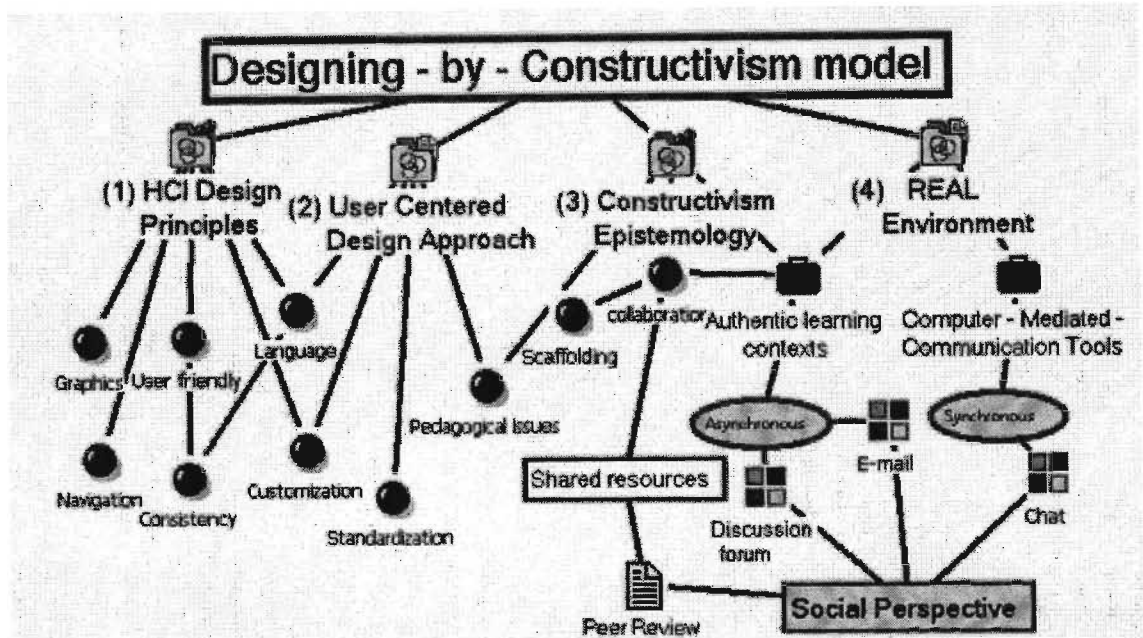
Figure 21: Pictorial model of Designing-by-Constructivism

Section 1: Identifying any problems that users encountered.

The purpose of this section was to help identify any difficulties experienced by the users. This was important, as it would serve as a basis for demonstrating improvements that can be made to the resource.

The users mentioned the following limitations, negative aspects, or problems regarding OLS: frustrations in logging into the system (4 participants); limited color options (6 participants); limited user control (7 participants); lack of user help manual to offer guidance when needed (10 participants); inadequate use of the facility by the course facilitator (noted by some biology students as the system was substantially used for notes delivery) and difficulties interpreting the error messages (12 participants).

Examples to support these findings are the illustrative quotations below, which were, extracted verbatim from the participants' interview responses.

1 (a) Did you experience any problems when using the resource?

(b) If yes, briefly describe the problems you encountered

Response 1

"Yeah, there were a couple of bugs in the system that was preventing my GroupWise email coming through the system, but I have reported that bug"

Response 2

"Very minor problems. Mostly have a particular nature. OLS is a very nice system only a few bugs. The overall use of the system I did not have any problems. It did not me long to learn how to use the system"

Response 3

"Yes at first I had a problem with logging..."

Response 4

"No, the system is ok as long as you know what you are doing"

Response 5

"Yes, the problem was not so much of OLS but authentication with the server, my login name was duplicated on the system. Networking did investigation that is two people with similar names but in different context, this led to me changing my login name"

Response 6

"Some features were not working well and it was problematic accessing it from different locations"

Most of the problems experienced by the users were related to logging in via the University of Natal authentication system and not to OLS per se. For example out of the 20 participants 4 experienced a problem with logging into the system.

2 (a). Did you encounter any error messages?
(b). If yes, were they helpful in identifying the problems?

Out of the 20 participants, 5 encountered error messages. Some of these problems were related with the logging into the resource. Below are the illustrative quotations, which were extracted verbatim from the participants' interviews responses

Response 1

"Yes, I encountered ... it was not very helpful; it was just telling me that the database was locked. This is a point of whether OLS should handle this better or I-chain should handle this better. A non-technically informed user would not understand this kind of message."

Response 2

"I saw an error message…Not all of them some of them were helpful but not all them."

Response 3

"Yes I did, there is a small programming problem as I try to move my courses into the system, I created some folders later I couldn't access those folders, that was a small programming error which was pick up quite easily and fixed…. Well, it didn't give the solution, it indicated there was a right security error, what I thought was that they hadn't given me the rights, whereas in fact it was a small programming error."

Response 4

"Yes the error was helpful, it said log in failed"

Response 5

"Yes, this were straight forward error messages, for example there was one error message which stated that you have been disconnected from the database and all you needed to do is to log on again"

3. Did you have any trouble remembering the options and operations within OLS?

This is another important question, which also helped to probe the problems that the participants could have encountered.

Most of the users did not experience any problem remembering the options and the operations within OLS after the first login. Verbatim examples of the participants' responses are given below.

Response 1

"No not all. There were a couple few buttons and fields that need to be renamed on a usability level, all in all it is very easy to navigate and it is very easy to remember where you've come from and where you are going to."

Response 2

"No, again getting back to this comment of ease of use and ease of navigation, the first time I went to it I had my expectations and they were largely met. I could find my way around very clearly and very easily. I knew I wasn't going into a fully designed product, I went with positive expectations and they were fulfilled."

Response 3

"No, there are very clear"

Response 4

"No, no no I found it quite easy to use"

Section 2: The experiences users had with the resource

This section presents the users experiences with the resource, which was determined by asking 7 unstructured questions in an attempt to find out the degree of user friendliness of the interface; the features they liked or disliked most about the resource; the improvements or changes they would wish to made on the resource; their perception of learning as part of a collaborative group; their perception of OLS as an online learning resource and the features of the resource that they felt could be substantially simplified.

A qualitative analysis determined a number of very positive themes including: clarity in the language used; the use of graphic was appropriate; the interactive and collaborative nature of the system was very good; overall consistency; strong customization ability, very strong navigation, and strong learning tools for example the chat, discussion forum and peer review tool. These themes were derived from analysis of 7 major key questions under investigation as outlined below.

1 Did you find the OLS resource to be user friendly?

With regard to this question, 19 interview participants responded to the effect that the resource was user friendly. One of the participants felt otherwise. Examples are the illustrative quotations below, which were, extracted verbatim from the participants' interview responses.

Response 1

"It is user friendly, I think it is built on a particular concept which I think is very good concept, I think that it does though need help documentation for people who are not used to that kind of thinking, but I think the design is really good it makes it very user friendly"

Response 2

"Yes, yes, it is clear you can see what you are doing, obviously anything you use the first time you bumble around a bit once you get used to the environment it is fine. The icons are easy to use. I think generally it is easy to use. "

Response 3

"It is user friendly because the language use is easy to understand..."

Response 4

"Yes, definitely it is user friendly but some of the things need to be improved here and there and I understand this is the first time it is being implemented."

Response 5

"For the most part, there were minor areas where I think it could be not as a good as it could be, for example the portfolio submissions it would be nice to have a section where you upload your portfolio before it and then you can overwrite it before the deadline. Otherwise by sending a portfolio the course facilitator ends up with so many copies of the portfolio. There are pros and cons to that."

Response 6

"Yes, it is but there is this time that you know it can get quite confusing when you have to work around to get to certain things. For example if you want to go to discussion message you have to go through a long process."

Response 7

"No, it is not quite perfect; it is still at the imperfect stage. Some functions are too deep for example one needs to navigate too much before accessing a particular tool like the chat. It also requires a help manual because we are learning how to use it through trial and error. It would be more users friendly if the links can be put on the side bar to avoid many clicks. The key thing is simplicity, it should be tried with students of high school to find out how they would use it, you know some schools are using learning resources and OLS is targeting students in all learning levels."

2   Which OLS features did you like most?

Most of the users liked the customization abilities, the interactive nature, document management tool, the ability to upload files at once and the learning tools of the interface. Examples are:

Response 1

"Really like the navigation was very strong, it is a very clean interface it is very easy to move around"

Response 2

"I liked the fact that it can be customised, I think particularly the strong learning tools the chat and the discussion forum. The discussion forum works very well, very much like a news group that exists on the Internet, and the ability to upload lots of files at once. It is quite user friendly."

Response 3

"The paper review, where you put your comment right to the text, this is a beautiful beautiful invention."

Response 4

"All of it, no, in essence the navigation, the whole navigation menu system, OLS is very clear, I admit that I am making that comment as someone who has used a computer for quite a bit of some time, I would like to see comments from people who are not computer familiar, not computer illiterate but users who are not familiar with online learning environment."

Response 5

"I like the discussion forum because it allows me to be open, to say my views and gives me a chance to get other peoples ideas..."

Response 6

"The ability to pull in an object without using the HTML code,..."

Response 7

"I like the file and document management feature the most they are easy to use and uploading downloading the files the ability to use the page bar to organise the pages of my course, I also like the fact that I could link very easily to materials on different parts on the server. The ability to have some courses available to only some students."

3   Which feature did you like least about OLS?

This question assisted in finding out the specific negative aspects of the system the participants did not like.

The participants gave varied responses to this question. Nine of them gave their response as none, 7 participants said that the font size is too small, while 5 participants mentioned something to the effect that they need more image support capabilities. Examples are:

Response 1

"Not being aware of any image management tools..."

Response 2

"Appointment and task features which I hardly used I did see any importance" (one user)

Response 3

"This a good question, one thing that I have noticed is that sometimes when I want to move back it takes me back further than I actually wanted to go"

Response 4

"Font small and printing was difficult..." (10 users)

Response 5

"Well I would say the window we use to submit articles is very complicated and not easy to use. It is not very user friendly and does not allow all the information that comes from text editors like images."

4   What would you like improved or changed in the resource?

Thirteen participants found no reason to improve or change anything in the system. The other 7 suggested the need to change some things, for example three users suggested the need to reduce the number of links (example see response 2), three users wanted to have the abilities to use colors of their own choice and icons that are relevant to their subject matter. One user wanted to have a confirmation indicating the portfolio submission was successful.

Response 1

"Well so far nothing, but it would be nice to see more learning tools. But I think it will probably be added, the ability to use video, video conferencing"

Response 2

"I think it is the link buttons, if they can be improved, a link that would take me straight to what I am looking for, for example instead of first opening communication before reaching the chat."

Response 3

"... Need... I think the learning tools are so far are quite magical, I think the peer review tool is wonderful, I would like to see more graphic gallery this can allow for accessibility of annotated gallery and use this in a creative way. These tools can make learning seamless and allow for collaboration. ... I would like to see more looks; there is a problem with increasing the font size. If you increase the font size it does not do so properly. This is ...I find myself battling with the font size. This would give more flexibility to the font and

more control to the users. I had a student who needed his font in gigantic form, therefore it is not good to exclude people unnecessarily"

Response 4

"...I would like to be able to view images on the paper review without having to write the HTML code on it for an image to show... "

Response 5

"I would like to have more options in terms of customisation and I would like to be able to add my own icons that are relatively relevant to my learning environment. For example as you can see this is a medical curriculum this icons in OLS are relevant to the computing environment, you see disk drive all sort of this that have to do with computers. For example I want to use an icon to demonstrate blood circulation I would like to have that capability"

Response 6

"The portfolio submission, it would be necessary to have a confirmation that the portfolio was successful sent, otherwise one needs to e-mail the course facilitator to find out if the portfolio was sent. "

5   How has learning as part of a collaboration group helped you? Or how do you think OLS will assist the learners in learning as part of a collaborative group?

The first question was asked to the participants who had already been involved in collaborative learning environments while those who were in the process of doing so were asked the other question. The aim of this question was to find out how much the resource has achieved or would achieve in terms of collaborative learning and interactions, which is a very important aspect in social constructivism (see Chapter 2).

The participants found this question to be very important as they agreed that OLS is grounded on such principles. However the second year Biology students had not made full

utilisation of the tools that enhance collaboration, but their next learning tasks that were to follow in the next 2 weeks required them to work in collaborative groups. Therefore they saw themselves involved in collaboration learning. Examples of responses given with regard to this question are:

Response 1

"I did go on a student as well. Though I did not collaborate I just observed. I think the discussion tool is exceptionally useful and the ability to review I think is going to be useful. I certainly would like to use that tool. For myself I think someone reviewing and being able to add comment on my article is very useful"

Response 2

"This has helped me, because I have learnt a lot of things that I did not know that other students made aware of and others that were obvious but I did not pick them up. This also stops a kind of competition between students."

Response 3

"I'm I would say greatly because I am dealing with a whole different group of people who have lots of different experiences, different ages, ages, culture, different initial fields of interest, this is the best thing that could have happened. Simply saying ... here are some text books go and read them and tell me what you think, yeah I would learnt from that but I have learnt more by dealing with other people.

The beautiful thing in a collaborative learning nobody loses as much as I might be competitive, I am competitive largely with myself, there some certain standards that I want to achieve and I am trying as much as possible, I am using the people around me to help me stay at that level, Because I am taking cognitive of their feedback and criticism. I think collaborative is tremendous I don't feel threatened. I hope no one does. We are collaborating not in the actual creation of the product but in the sharing of knowledge. We collaborate up front before the actual creation of the product."

Response 4

"Oh I think it is designed specifically around that approach, the chat, discussion forum is embedded. If possible each activity can have its own chat or discussion forum. The design is very collaborative. I have been using it collaborating with one of my student who is using it for his project."

Response 5

"Yes it has to a great extent due to the way it is designed it enhances collaboration and sharing among students and that is one of the best features of OLS in that it enhances collaboration"

Response 6

"...I am planning to make more use of the tools in the next part of the course, because collaboration and cooperation is an integral part of this Biology course...."

6. What is your perception of OLS as an online learning resource?

This question was presented with an aim of investigating users' perceptions and attitudes towards OLS as an online learning system.

All the users interviewed agreed that OLS was a suitable online learning resource. One interesting theme that emerged from the responses given to this question was that the participants felt that computer based learning environments can offer a better and vibrant support and learning environment.

Examples are the illustrative quotations below, which were, extracted verbatim from the participants' interview responses.

Response 1

"...Actually in appearance it looks a lot better, it seems to be a lot easier to use as a course designer and possibly as a student and because it looks like a normal computer application it might actually be more user friendly..."

Responses 2

"I think it is brilliant, I think it will be a very successful resource..."

Responses 3

"Flexibility, I think it is very nice we can log in the resource anytime we want, this is the way to the future...all lecturers should adopt this method of learning"

Responses 4

"Well it is a very good one, it designed for that, it is very usable and I think in very many ways which we may not have thought about."

Responses 5

"Relatively easy to use but powerful tool to use for facilitating online learning"

Responses 6

"Got a way to mature into a complete support tool, it has a lot of potential. It is a tool that enables us to get along it is not an end in itself. Considering this is new it is pretty impressive."

Responses 7

"It is very user friendly is quite professional, it is not clustered and is organised"

7 Do you feel that some features of the resource can be substantially simplified?

All the participants apart from three felt that the resource was quite simple and straightforward already. These three felt that the number of clicks should be minimised.

Examples are the illustrative quotations below, which were, extracted verbatim from the participants' interview responses.

Response 1

"It seems to me to be quite simple already. I may have spent longer than I should have although I did not struggle with the peer review... Although it was very easy to use but I found maybe I spent a few second than I should have. But I can't say how it could be improved because it was quite straightforward."

Response 2

"No not really, I probably think more resources would be added to it, but it is very very straightforward and easy to use."

Response 3

"I think so yeah, like I said the link buttons getting to certain things and the icons I think they can be simplified."

Response 4

"I would be hard pressed to find anything that could be simplified without taking away some of the essential utilities in it. The answer is yes but I would be very cautious to tell which ones. I look at things and ask myself is different better? If it is not better there is no need to change it."

Response 5

"Like I said the submission window can be simplified"

Response 6

"I don't see anything being simplified anymore than it is"

Response 7

"Yes, for example navigating from first page into the chat forum requires about eight clicks, if we can have different links to those features, however this may cause clustering but if well done it can be successful. Also if the student can be identified by system e.g. by their students numbers or names"

Section 3: Any tools and elements users would like added to the resource

This section aimed at identifying any additional tools and elements that users would like added into OLS. This was done through asking them the tools that they thought would be added to OLS and why.

Table 6: Various tools and elements users suggested should be added

Tools/Elements	Reasons	Illustrative quotations
White board	Seven users felt that it would be a good idea to add more collaborative and visual tools.	*"… A persistent whiteboard. This is a whiteboard equivalent of the discussion list, where you can go to a whiteboard area put an image on add some annotations and when you log out it says there for sometime"* *"…More collaborative and visual tools… like the video conferencing and people to draw things visually and represent their knowledge visually and collaborate on it…. Persistent whiteboard…"*
Image management tool	Three users expressed interest in graphic management tool	*"Certainly I would say something around graphics,"* *"An image management tool … as images are important in learning"*
Logging off button from resource	Two users expressed a lot of interest in having a logging off button like in the case of e-mail application.	*"…There is no option to log out, maybe a little button that says log out and after that a page that says that you are now logged out …"*
New Postings button	One user felt the need of having a new posting button.	*"…A tool that allows a course facilitator to see on the front page whether there are new postings, instead of entering into each course that you are facilitating to check for new postings."*

Search Engine	One user wanted the system to have a search engine	*"A search engine, probably, one that is advance and specifically geared to this kind of learning."*
More user control abilities	Ten users expressed this view. For example for working offline, minimize button. Also the ability for students to change some of their details.	*"...On article review the paper evaluations there are students who work from home, if they... can save these articles and work from home. The other problem one cannot minimise."* *"I would like the students to be able to change their user profiles, for example where we have given name and preferred name, I don't know the students preferred name and their email address, some of them don't use their university email address. However this does not mean they change other things like student number"*
More student management capabilities	One course facilitator wanted to see easy student creation capabilities. The others said they did not have problems, as their students were few.	*"What I hope to see with OLS is where I shall be able to upload from the university system soon. Uploading 90 students one at a time is a bit of a slump, you find I have to modify the spreadsheets that are produced ... take me a lot of time... That part I think can be streamlined"*

A spell checker and audio files	One user expressed this interest	*"A spell checker and audio files as digital media students we may want to demonstrate something and share with peers, therefore, it should accommodate multimedia and also be able to run spell checking."*
User on-screen identification	One user expressed the need for a personalised identity display on OLS homepage	*"... If the student can be identified by system e.g. by their students numbers or names."*

4.4 Further discussions and conclusions

This section aims at further discussing the analysis with respect to the literature review. In this section attempts to integrate the theoretical and practical motivation of this research are made. Before these further discussions in section 4.41 some of the limitations of this study will be addressed. More reflections on this research will be given in Chapter 5.

4.4.1 Limitations of the study

Some users were shy to participate in the study especially in the interview. This was the first time the biology students were learning in an online learning environment therefore the lack of knowledge of a computer learning environment could have affected their responses as well as cause the fear to participant in the interviews. At the proposal stage the researcher feared the possibility of difficulty in translating the events, behavior, and attitudes into scientifically useful information. However, this did not happen, as the answers provided by the participants were straightforward.

It was quite unfortunate that the researcher was not able to provide users with some tangible motivation, which could have drawn more users to participate. Nevertheless, the promise of the dissertation being made available to the users served as a motivation of some kind.

4.4.2 Emerging pedagogy and specific aspects of the OLS referred to by users

The term scaffolding was originally coined by Bruner, Wood and Ross (1976) as a metaphor to describe the effective intervention by a peer, adult or competent person in the learning of another person. That is the actual developmental level of the learner compared with the level of potential development that can occur with guidance or collaboration with a more competent person. While the Vygotskian perspective provides the theoretical anchoring for the concept of scaffolding by making an explicit connection between social interaction and cognitive development, other forms of support can be provided by technology thus enabling learners to engage in cognitive change and skills advancement.

Learners can be supported in the learning process by using different online learning tools, which support dialogue, collaborative activities, Problem Based Learning (PBL), authentic activities amongst others (see Table 7 below). From qualitative analysis these tools (e.g. chat, peer review and the discussion forum) and elements (e.g. customization themes) were found to have contributed greatly in collaborative learning, overall achievement of learning goals and objectives and user satisfaction towards OLS. Also integrated into the system are a number of University resources to form a coherent system, which supports the development and deployment of on-line learning resources such as the appointments and tasks. The same was observed in the quantitative result analysis.

Table 7: Tools and elements users appreciated and their contribution towards learning

Tool/ Element	General perception and contribution of each	Scaffolding afforded by the tools	No. Of user
Chat	The synchronous nature provided for a high degree of real time interaction.	Online-mentoring.	15/20
Discussion forum	Asynchronous nature provided for reflective thinking, exchanging of views and ideas and collaborative learning.	Guided reflection, online mentoring and group processes	All
Peer review	Provided for critic, improvement of work in preparation for portfolio submission and for collaboration.	Peer support, online mentoring and group processes.	14/20
'My Module' and hyper-linked access to courses	Provided for easy and organized access and navigation of courses and online resources to the users.	Sharing resources and self regulated learning.	All
Customizatio n themes	All the users commended the resource for the customization capabilities. This is because they felt that they could change the look-and-feel of the resource using the themes/skins and/or icons links available on the customization side bar tab. The other reason was that the theme consists of a set of design and colour elements that give the application a consistent and well-designed appearance. The number of different sets of icons available was impressive, which allowed users to change the icons as they pleased.	Flexibility, User control.	13/20
Appointment and tasks	There were mixed feelings towards this tool. Some viewed it as a very important tool for managing their electronic diary while others did not find it to be necessary.		7/20
E-mail	The integration of the e-mail facility with the existing GroupWise e-mail was found to be very important for collaboration and exchange of ideas.	Guided reflection, peer support & online mentoring	16/20
Document management tool	All the four course facilitators liked the document management feature, which allowed them to manage their files.	Sharing resources	4/4

From Table 7, it can be concluded that OLS has been built with an integration of scaffolding features and has utilized the design principles and processes, which can offer support for web-based courses. Some examples of key indicators of scaffolding in OLS are: the provision of learning tools to help the learners solve and share their problems with others; the multiple CMC channels that are integrated in the resource enable discussion, conversion and exchange of ideas; 'My Modules' and peer review tools provide support for collaborative tasks and development of higher order cognition; the document management tool supports the course facilitators in embedding scaffolding as they organize the modules/courses and learning activities in a spiral manner. Oliver and Herrington (2001) stress that online learning environments need to be adaptable and flexible enough to provide students with supports necessary to move from their level of actual development to their level of potential development.

However, some users had not made full use of these tools and elements as they were still in the early phases of getting acquainted with online learning. Examples to support this are contained in the illustrative quotations below, which have been extracted verbatim from a course facilitator interview response.

"I think it has a lot of potential as a learning resource. I think I haven't explored its full potential, I have only used it to meet my immediate need, I can see a lot of things that could be fun to do for the students, which I hope to do

"... I am hoping this will make communications for the students much easier using the chat and discussion forum... they can use the system for co-operation which is an integral part of the course, they can use the system to link to other sites at the university, this would allow the students to be part of a much bigger picture than just one module"

4.4.2 Emerging deviations

A comparison of the actual results with the pilot study showed a great difference in the results, that is the pilot study showed a higher degree of user satisfaction with the resource. The reason could be that the users who participated in the pilot study were students who were undertaking their studies in an online learning environment and they had more experience of computer-based learning. Some of the Biology students declined to participate in the study. The reasons they gave were that they were unable to log into the system and expressed frustration as a result, while others claimed that they were too busy with other courses hence they had limited time to be actively involved in an online learning "classroom".

CHAPTER FIVE
CONCLUSION AND SUMMARY

5.1 Introduction

This chapter focuses on conclusions around the key features that contributed to successful evaluation of OLS. The results and discussions in Chapter 4 are also further explored and related to *'Designing-by-Constructivism'* model. The proposed recommendations are based on the research findings. Lastly, a summary of the dissertation is made (see Figure 1 for pictorial representation of this chapter).

These conclusions will be ordered according to the research questions that were stated in Chapter 1. How can online learning systems be designed around the user needs? Which are the most important HCI principles in the design of learning systems? Which are the most important features and tools that should be integrated in learning software? How can the emerging pedagogies influence the design of learning systems? Which are the most important themes to be considered in the design of educational software? How do people perceive online learning? How does design of educational software influence learning - such as collaboration, situated learning and scaffolding? These research questions were: how can educational systems be designed around the user needs? Which are most important HCI principles in design of learning systems? Which are most important features and tools that should be integrated in learning software? How can the emerging pedagogies influence these designs? Which are the most important themes to be considered in design of educational software? How do people perceive online learning? How does the design of educational software influence learning - such as collaboration, situated and scaffolding?

Indeed it is possible to design learning systems around the user needs, thereby improving the human computer interaction and at the same time providing a learning environment where the learners are able to construct and share ideas. The main elements of the *'Designing-by-Constructivism'* model were present in the resource.

The first research question was concerned with designing learning systems around user needs (User Centered Designing). The UCD approach emerged from the realization that evaluation methods associated with each design cluster were expensive or took place late in the system's development life cycle and raised the need for this pragmatic approach. Its main efforts are towards techniques and tools that focus on the requirements of end-users and provide early evaluation feedback. UCD cuts costs and increases user satisfaction and productivity. It was possible to derive from the UCD approach the actual problems that the users were having with OLS, for example some users experienced problems logging into the system, others encountered bugs (see Section 1 Question 1). Furthermore, implementing educational software in an actual system requires that designers understand who the users are, how they do their work, the purposes for which they will use the resource, their needs and prior knowledge, and their response to the prototype.

The flexibility in the OLS design enabled the users to take control and responsibility of their learning process; this was especially the case of users involved in a purely online learning environment. The users agreed that the CMC tools especially asynchronous tools, allowed them to reflect as they participated in communication processes. It is very interesting to note that the system is designed in such a way that it can be used in both mixed mode of learning and in purely online learning mode. The design of OLS is to a large extent user centered; nevertheless, as noted in the qualitative analysis some users expressed the desire to have more control in terms of the icons and the peer review tools.

The second research question was geared towards verifying whether HCI principles were applied and considered in the OLS design process. Based on *'Designing-by-Constructivism'* model and theoretical aspects of designing, it emerged that the system met most of the design principles that should be found in a good interface, for example use of color, use of graphics, navigation, human memory limitations (see quantitative analysis results and discussions). However some users expressed interest in the ability to have more control over color choices, font size, icons and customization themes (see qualitative analysis).

The third research question related to the important features and tools that should be integrated in learning software. The features and tools that users felt should be added into the system have been discussed in Table 6. In summary these are: white board, image management tool, logging off button, new posting button, a search engine, more user control capabilities, more student management capabilities, a spell checker and user on-screen identification. Similarly the tools that they appreciated have been outlined in Table 7 and the features they like most discussed in Section 2 Question 2. These are: chat, discussion forum, peer review, 'My Module', customization themes, appointments & tasks, e-mail and document management tools.

The fourth research question was concerned with how emerging pedagogies can influence the design of learning systems. From the combined quantitative and qualitative results obtained, it emerged that the participants viewed OLS design to be grounded on the constructivist design (refer to emerging pedagogy in Chapter 2). The nature and the tools in the design allowed for collaboration, interaction, cooperation and scaffolding learning (see results and discussion Chapter 4). However as mentioned earlier some users expressed the need for more tools that can enhance collaboration (see Table 6).

From the interviews conducted, the three stages of learning described by Brunner (1960) (enactive, iconic and symbolic mode) (see page 17) have aided the users relating OLS to other computer environments that they were aware of. As they manipulated and discovered how to use the resource it was noted that this involved an internal reorganization and association of previously known ideas of computer environments in order to establish a better fit between those ideas and regularities of an encounter to which they had to accommodate. Most learnt how to use the resource through trial and error; this can be related to Piaget's cognitive constructivism philosophy of assimilation and accommodation leading to adaptation.

From the study we share the view of several researchers for example Jonassen (1996) and Jonassen & Reeves (1996) that technology is a very important cognitive tool.

Technologies, such as learning resources, can help build knowledge foundations, which will engage the learners more and result in more meaningful and transferable knowledge; learners function as designers using the technology as tools for analyzing the world, accessing information, interpreting and organizing their personal knowledge and representing what they know to others (Jonassen, 1996). Examples to support this have been provided in this dissertation. Cognitive tools help in knowledge construction and not knowledge reproduction. The knowledge constructed by the learners reflects their comprehension and conception of the information.

The fifth research question aimed at establishing the most important themes that can be considered in the design of educational software. The most important themes that emerged from the analysis are: clarity in the language, used the use of appropriate graphics, interactivity and collaboration, overall consistency, customization ability, strong navigation and strong learning tools (for example the chat and discussion forum).

The sixth question was about the perceptions of users towards online learning. The user' perception was that virtual classrooms offer more increased access to quality of education. Similarly, they seemed to be reasonably satisfied with OLS and showed a positive attitude towards the resource.

The last research question was geared towards determining how the design of educational software can influence learning - such as collaboration, situated learning and scaffolding. From the qualitative analysis of Question 5 and 6 in Section 2, it is clear that the users agreed that OLS is specifically designed around these approaches. Similarly, Table 7 outlines the tools and elements that users viewed contributed to learning, with special regard to the scaffolding accorded by each.

5.2 Recommendations

On the basis of this study, it seems reasonable to draw several recommendations to help improve the quality of the new resource and to make suggestions for future research in summative or iterative evaluations.

The evaluation identified minor technical problems associated with logging into the system. However this problem has nothing to do with the resource in itself but was due to I-Chain, the University of Natal authentication system. Nevertheless, authentication services require greater attention and should provide appropriate error messages when authentication fails.

Similarly it would be a good idea if attention could be paid to the tools and elements that the users suggested could be added to the system for example the white board and image management tools (see Table 6). In addition, some users expressed the desire for more autonomy in terms of the peer review window, more customization themes, colours and icons (see qualitative analysis section 2 Question 4). With these few recommendations it is perceived that OLS will be ready for full implementation in the beginning of the year 2004. When fully implemented, the objectives and grounding of OLS will become clearer and more authentic to the University community at large.

5.3 Further Research

The research focused on the preliminary evaluation of HCI design of OLS. Other research can be carried out after the full implementation (summative and iterative evaluations) to determine the users' perspective at different stages of implementation and improvements. This is because user interface technology is dynamic thereby offering new interaction possibilities at different stages of the life cycle of a product. Similarly, the preferences of users change as they gradually master new interfaces. Would the results be similar if the subjects were doing other modules that are not computer related? Will the perception of the users be different after a certain period of usage?

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In this study one group of learners and course facilitators had a good computer background. For this reason the study can be replicated where the participants are not learning a computer related course. The other group (biology students) did not have a good computer background nevertheless they were learning in mixed mode environment. Also research on the effectiveness of individual courses being offered using OLS can be done to determine their success.

5.4 Summary

The wish to revolutionize learning is not new. It is also one of the reasons this study was conducted. Other impulses for this study are the new possibilities provided by the use of the WWW and the Internet. It is assumed that new possibilities offered by online learning systems can help to revolutionize and support learners in an efficient way. This research focuses on the HCI preliminary evaluation of a new online learning resource and the decisions to be taken before its overall implementation. Thus, the research questions of this study are: What are the existing approaches in the design of educational software for supporting students and course facilitators via web based learning environments and how do these approaches reflect the paradigm shift (from instructivism to constructivism) about learning? What are the most important design features, tools and elements of supporting the users in this learning environment?

In an attempt to answer these questions, several existing approaches, principles and theories of designing and supporting learners are studied. As a background for this study the constructivism epistemology was used, where active learners construct new ideas or concepts based upon their current or past knowledge (Bruner, 1960). The two constructivism strands were used - social and cognitive constructivism strands. Concepts such as situated learning, collaboration, authentic activities and scaffolding were used.

In order to translate theoretical motivation to practice for evaluation of educational software, the constructivism epistemology, the REAL environment, the UCD approach and

the HCI design principles were integrated to form a single reference framework *'Designing-by-Constructivism'* model

To provide more focus for the second research question, quantitative and qualitative research instruments namely a questionnaire, evaluation matrix and interview sheet were formulated.

To provide meaningful information from the data generated and to improve the efficiency of analysing the data, the analysis were aided by SPSS and NVivo, quantitative and qualitative analyses computer software respectively. The results analysis indicates that the resource supports collaborative learning and the use of authentic activities in learning. This serves as an intrinsic motivation to most of the users. The result shows high degree of users satisfaction and appreciation of OLS resource. Overall, the participants are satisfied that the overall OLS design met their needs. The major contribution being *"OLS is interactive and user friendly"*. However, some users have expressed the desire to have more tools incorporated into the resource. Others have expressed concern over the problem to do with logging into the system.

Last but not least

After examining the literature on design of educational software and constructivist principles, a complementary relationship between designing and learning within a constructivist framework seems sound and advantageous to this study. Technology, such as online learning can provide the vehicle for accomplishing constructivist-teaching practices that have been discussed in this dissertation. The sample size of this study was large enough to provide valuable information about the users' perception of OLS. It is quite apparent that the users do enjoy learning in an online learning environment especially where the system is interactive in nature.

As illustrated from this research, it has been observed that preliminary evaluation of educational software forms a very important guide in the overall implementation and

success of the system. It is also important to monitor the design process by having different researchers conduct iterative evaluations at different developmental stages.

5.5 Open Learning System main features (Snapshots)

Below are some OLS snapshots showing different themes and features (Figures 22, 23 and 24). Figure 22 shows the OLS home page, which contains a welcome message, different navigation links on the left and the main document page, which in this case contains the University resources that are integrated into the resource. Each of the OLS headers contains a consistent header, which is applied across every page in the site. The customization theme used is called GameSpot and the icons set used is called MMX.
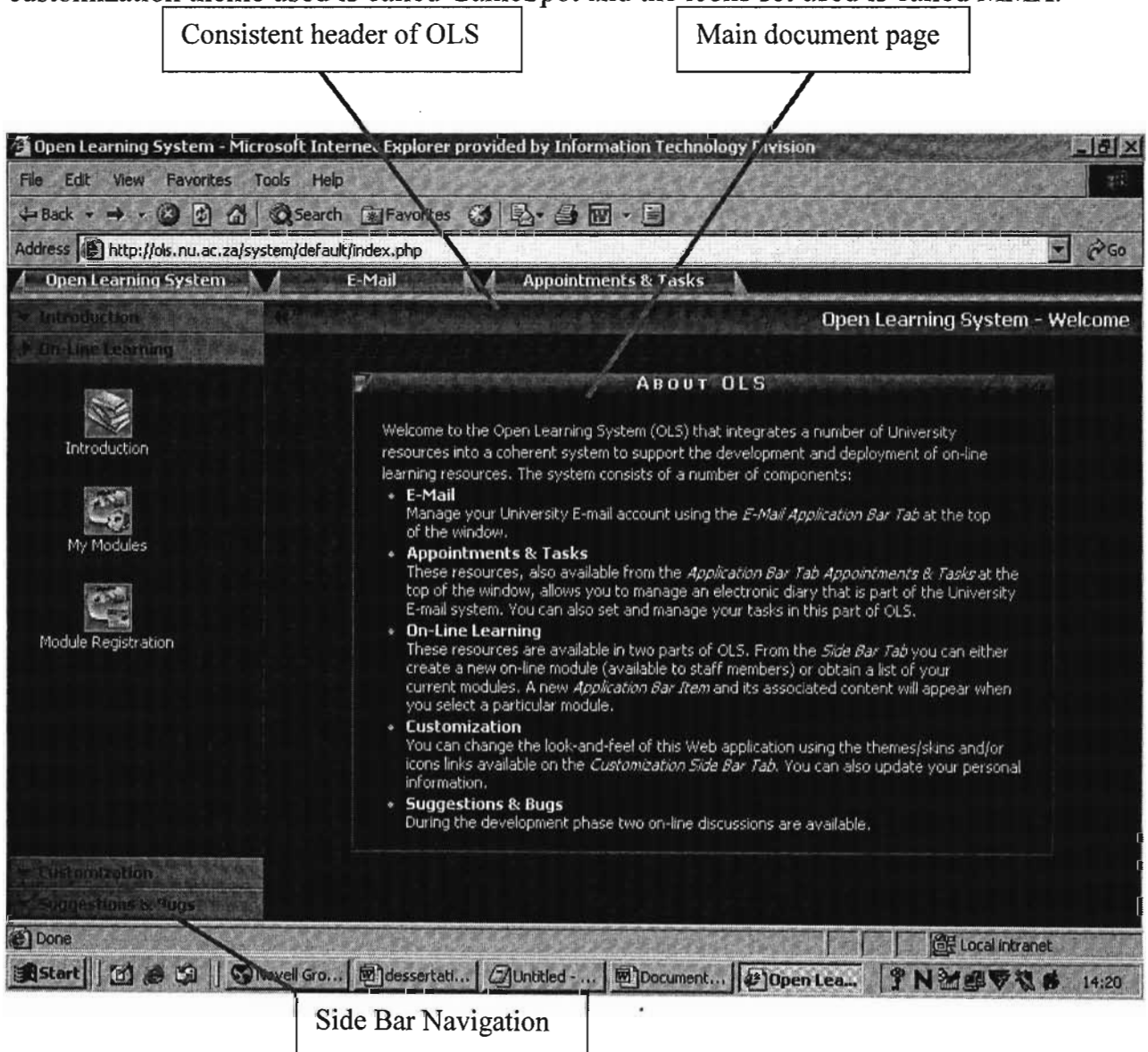
Figure 22: One of the different customization theme and icon

Figure 23 shows another OLS page with a different customization theme called iMac and an icon set called FausS-Ruby. The main document page shows links to some modules that the researcher had been undertaking through OLS.
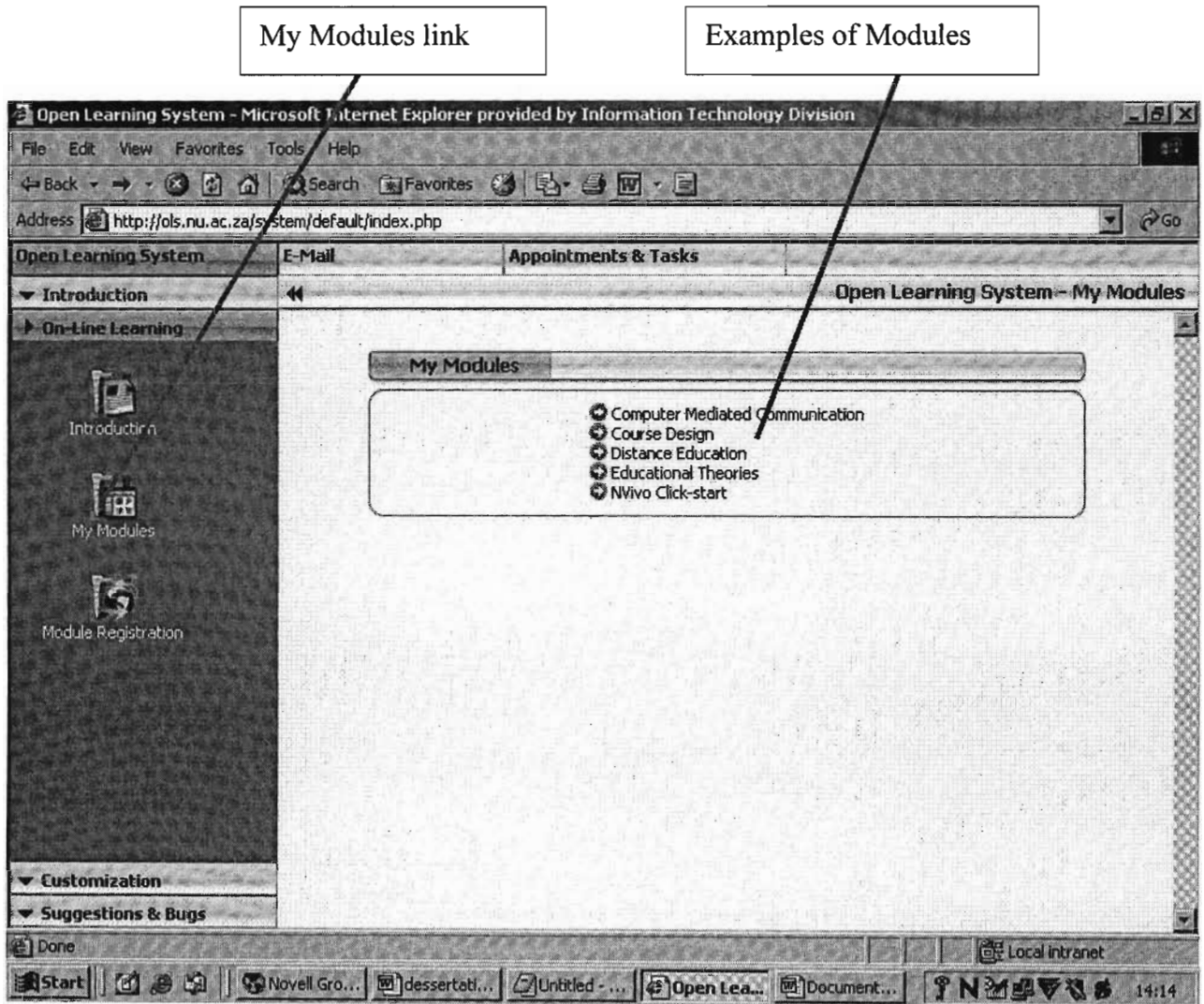
Figure 23: Another of the different customization themes and icon

Figure 24 shows another OLS page with the default customization theme and icon set called XP. The main document page shows an icon selector, which contains four icon sets a user can choose from with XP icon set displayed above and FausS-Ruby set below. This web page dialogue is accessed via the icon link on the left tab.

Figure 24: OLS home page with examples of icon selectors

Figure 25 shows another OLS page with default customization theme and FausS-Ruby icon set. The main document page displays the theme selector, which contains three themes a user can choose from with GameSpot theme being on view. This web page dialogue is accessed via theme/skin icon shown on the left tab.
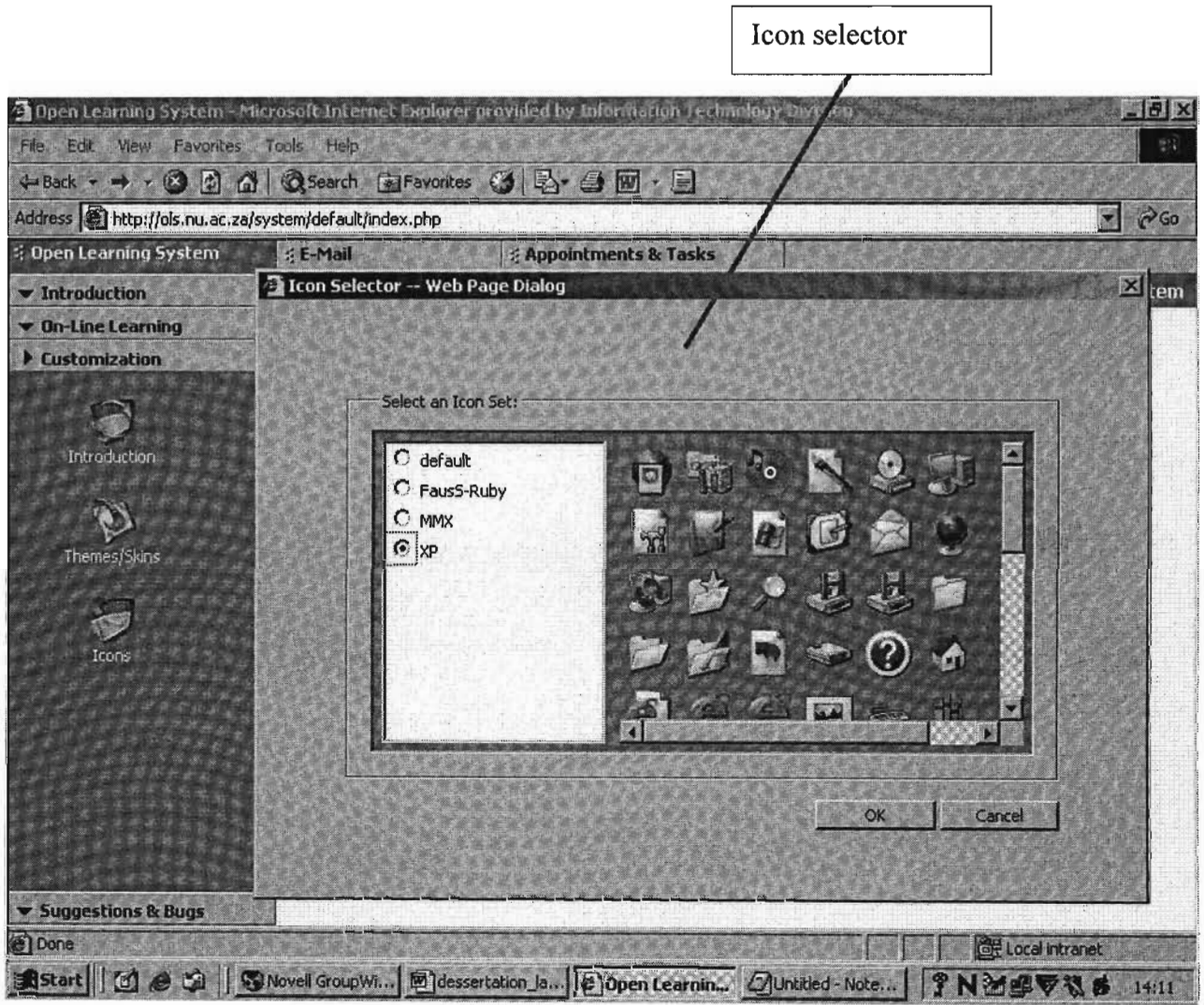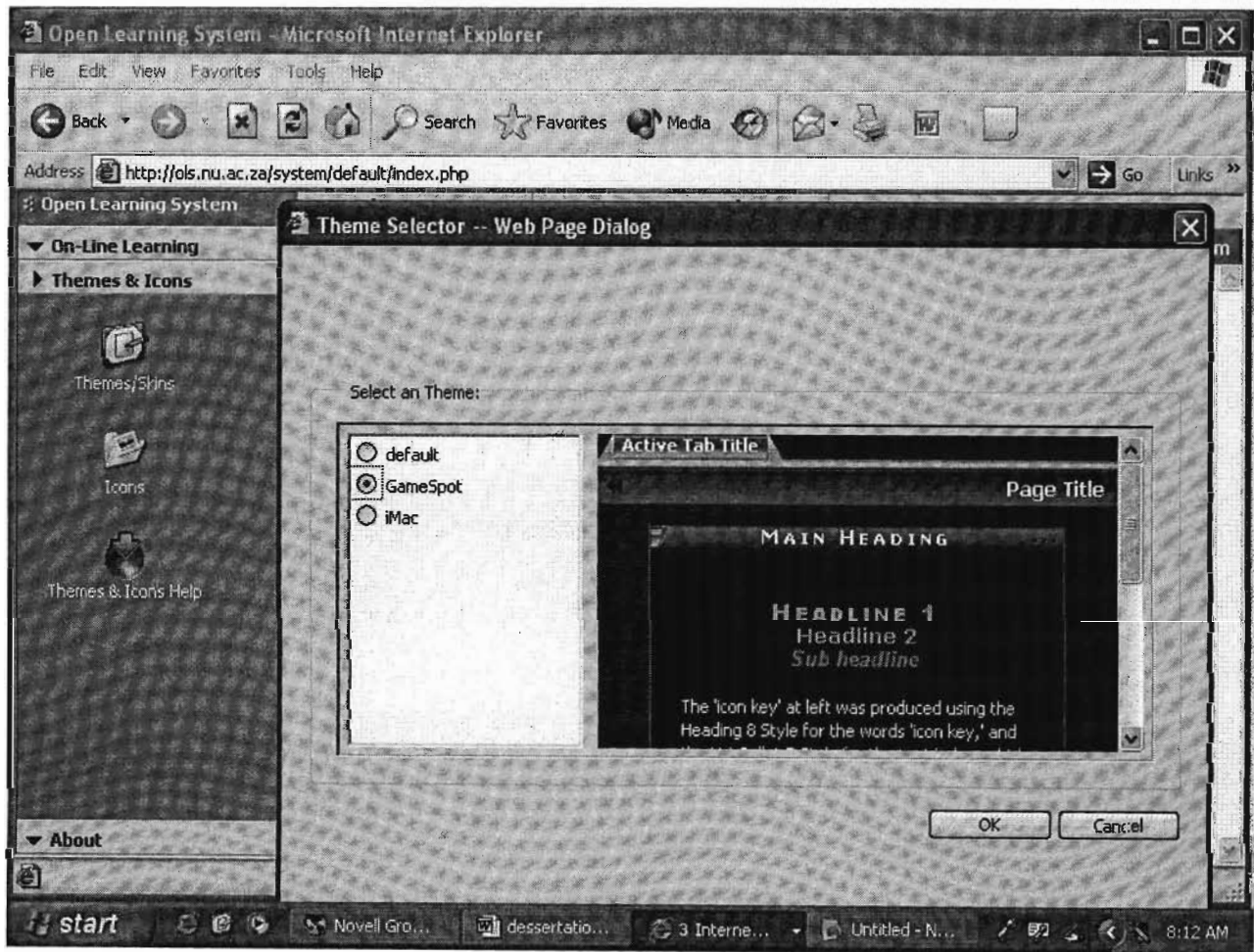

Figure 25: OLS home page showing examples of theme selectors

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APPENDIX 1

Dear respondent,

<u>Evaluation Questionnaire</u>

The main objective of this study is to examine the Human Computer Interface aspects of the New Online Learning Resource - Open Learning System (OLS), which you have been using for the last few weeks. The focus of the study is to:

- o Investigate OLS interaction on the user - usability, efficiency, effectiveness and satisfaction.
- o Assess the extent of the resource functionality and
- o Identify specific problems in design of OLS (that is, aspects of design that cause unexpected results or confusion).

I acknowledge that the questionnaire is long and complex and I would appreciate if you would respond to all the questions. This research is solely for the purpose of academic use and all answers to the questionnaire will remain confidential. Your help is greatly appreciated.

If you would like to have a copy of the final dissertation do not hesitate to contact me through my email address below.

Please add your written comments about any item at the end of the questionnaire in the spaces provided.

Best regards

Wanjiru E. Gachie.

SECTION A: DESIGN OF THE RESOURCE

Please select the number that most appropriately reflects your impression about using Open Learning System (OLS). When answering the statements, if you feel that you strongly disagree with a particular statement, circle 1, where 1 means, "Strongly disagree". If you feel that you strongly agree with a particular statement, circle 4, where 4 means "strongly agree". If your feelings are less strong circle one of the numbers in the middle.

No.	Description	Strongly Agree	Agree	Disagree	Strongly Disagree
1	Navigating between the pages was not difficult.	1	2	3	4
2	Computer related terms were appropriately used	1	2	3	4
3	I clearly conceived the error messages	1	2	3	4
4	Using the resource was not difficult	1	2	3	4
5	It was not difficult to gain access to the resource when I logged in	1	2	3	4
6	Appropriate authentication and security features are present	1	2	3	4
7	Navigation between different part of the resource is logical	1	2	3	4
8	The tools used support my learning style	1	2	3	4
9	Learning new features was not difficult.	1	2	3	4
10	The human memory limitations were considered	1	2	3	4
11	The language and format used is well expressed	1	2	3	4
12	The resource encourages collaboration and interaction	1	2	3	4

SECTION B: PERCEPTIONS OF QUALITY

The following refers to your perceptions of the resource. Please evaluate the design characteristics of OLS based on their consistency qualities. E.g. are the icons consistent

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with their functions. Is there standardization in the characteristics of the resource features? Use the scale below

1= low consistency

2 = somewhat inconsistent

3= somewhat consistent

4= high consistency

No	Characteristics	Low consistency	Somewhat inconsistent	Somewhat consistent	High consistency
13	The colour use is:	1	2	3	4
14	Sequence of displays are:	1	2	3	4
15	Terminology use is:	1	2	3	4
16	Character contrast with background is:	1	2	3	4
17	The graphics used are:	1	2	3	4
18	Links and navigations are:	1	2	3	4
19	The Interface design is:	1	2	3	4

SECTION C: THE LEARNING RESOURCE ATTRIBUTES

In this section your views towards some of the elements used in the new online learning resource are examined. Please rate how important the following elements are to you as a user. If you feel an element is not very important circle 1, where 1 means "Not very important". If you feel an element is very important, circle 4, where 4 means "very important". If your feelings are less strong circle one of the numbers in the middle.

No	Element	Not Very important	Not Important	Important	Very Important
	Email	1	2	3	4
	Appointments & Tasks	1	2	3	4
	Calendar	1	2	3	4
	My Modules	1	2	3	4
	Discussion forum	1	2	3	4

Chat	1	2	3	4
Icons	1	2	3	4
Customization themes	1	2	3	4

SECTION D: THE OVERALL DESIGN

Please critique the overall quality of the learning resource. Note that there are no right or wrong responses to the questions. Please give your own opinion. You can do this by writing the answer that you consider applies most.

28. Learning the operations was ------------------------ (Very difficult, Difficult, Easy, Very easy).

29. Human memory limitations were -----------------------------Vastly Overwhelmed, Overwhelmed, Are respected, Are vastly respected).

30. Use by different levels of experience was ---------------- (Not highly accommodated, Not accommodated, Accommodated, Highly accommodated)

31. Overall displays ----------------------(Very cluttered, Cluttered, Uncluttered, Very uncluttered)

32. Metaphor use ------------------------(Very inappropriate, Inappropriate, Appropriate, Incredibly appropriate)

33. Exploration of features ------------------ -----(Immensely repulsive, Repulsive, Attractive, Immensely attractive)

34. The overall resource is------------------ (Extremely difficult, Difficult, Easy, Extremely easy)

35. The overall reactions ------------------------(Very frustrating, Frustrating, Satisfying, Very satisfying)

Additional Comments or suggestions: --

AN EVALUATION MATRIX

The purpose of this evaluation matrix is to assess the effectiveness of the resource. Please rate the design features of the OLS. Put stars in the rating scale on the column provided using the following key. Where

- **4** stars imply the element is **excellent.**
- **3** stars imply the element is **good**
- **2** stars imply the element is **fair**
- **1** star implies the element is **poor**

Evaluation Item	Rating Scale
Colour	
Metaphor	
Language	
Information Presentation	
User Control	
Graphical User Interface	
Visual Consistency	

Thank you very much for participating in this project!

INTERVIEW QUESTIONS

SECTION A: IDENTIFYING ANY PROBLEMS THAT USERS ENCOUNTERED.

The list of questions below will help to identify any difficulties experienced by the users. They will also be useful in demonstrating improvements that can be made to the interface. They will be productive and lead to constructive suggestions because I will be able to pursue specific issues of concern.

1. Did you experience any problems when using the Open Learning System?
2. If yes, briefly describe the problems that you encountered.
3. Did you encounter any error messages?
4. If yes, were they helpful in identifying the problem?
5. Did you ask for any assistance when using the resource during the period?
6. If yes, approximately how many times and why?
7. Did you have any trouble remembering the options and operations?
8. Briefly describe them

SECTION B: THE EXPERIENCE USERS HAD WITH THE RESOURCE

9. Did you find OLS resource to be user friendly?
10. Which OLS features did you like most?
11. Which features did you like least about the resource?
12. What would you like improved or changed in the resource?
13. How has learning as part of a collaborative group helped you?
14. What is your perception of OLS as an online learning resource?
15. Do you feel that some features of the resource can be substantially simplified?
16. If yes, which ones?
17. Briefly describe how you went about accomplishing most your tasks?

SECTION C: ELEMENTS USERS WOULD LIKE ADDED TO THE RESOURCE

18. Which tools would you like to see being added to OLS?
19. Briefly describe why you would like to see these tools being added to the resource?